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ABSTRACT

This publication is part of the study materials for the distance education course, Adults Learning: The Changing Workplace B, in the Open Campus Program at Deakin University. The first part of the document analyzes the relationship between technology, skill, and work within the context of the debates concerning deskilling and managerial control strategies and the significance of technology and the organization of work. The following topics are discussed: technology and the organization of work; the deskilling debate (the upgrading, deskilling, and social construction theses; the Touraine and mixed-effects hypotheses; and the agnostic position); the origins of technology; and the flexible specialization thesis (the relationship between the flexible specialization thesis and skills and the limits of flexibility). Contains 56 references. The following papers constitute approximately 85% of the document: "New Technologies, New Skills" (P. Adler); "Technology and Deskilling: The Case of Five Principal Trade Areas in New South Wales" (D. J. Davis); "Intersphere Automation--The 'Factory of the Future'" (R. Kaplinsky); "Information Technologies, the Service Sector and the Restructuring of Consumption" (P. Blackburn, R. Coombs, K. Green); and "The End of Mass Production?" (K. Williams, T. Cutler, J. Williams, C. Haslam). Concluding the document is a 79-item annotated bibliography. (MN)

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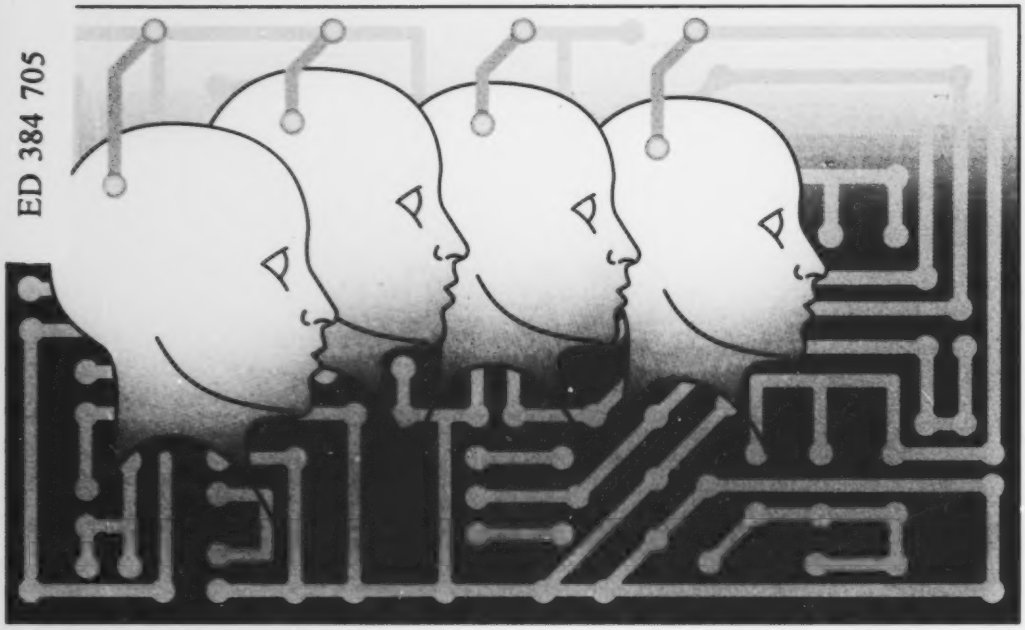

TECHNOLOGY AND THE ORGANISATION OF WORK

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CRAIG R. LITTLER

EEE701 ADULTS LEARNING: THE CHANGING WORKPLACE B

TECHNOLOGY AND THE ORGANISATION OF WORK

CRAIG R. LITTLER

Deakin
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SERIES INTRODUCTION

The nature and purpose of education in the workplace has been the subject of much debate in Australia in recent years. While the vagaries of local and international competition have led many firms to reconsider the role of their workforce and the training requirements this entails, governments have been equally keen to adapt existing education systems to the perceived needs of industry. Leading union bodies have been distinguished in this debate by their pro-active role, outlining the path by which a reconstructed industrial climate can win the nation a new place in the world economy.

The series of monographs of which this volume is a part explores the approaches to learning currently modeled within industry. In the process the question inevitably arises as to whether existing orientations and practices are in the best interests of the various stakeholders in the workplace.

The arguments developed in these monographs address themselves to a range of contemporary issues in industrial education. To date, prevailing approaches have rested upon narrow, instrumentalist notions of learning; in their different ways, the writers have set out to challenge this orthodoxy. In doing so, they highlight the silences—on questions of gender, class or ethnicity—that underpin the behavourist outlook still dominant in the world of training.

In preparing this series of monographs, the course team has sought to address issues that are of fundamental concern to those involved in the complex and demanding field of workplace learning. It is hoped that, in its own modest way, the pedagogy we have developed can serve to exemplify a different notion of what industrial education might become.

TECHNOLOGY AND THE ORGANISATION OF WORK

Introduction

This monograph aims to provide an overview of the research on and analysis of technology, skill and work. As the literature in this area is vast, and growing constantly, I have chosen to create some order by focusing on the two major debates of the past twenty years concerning technology and the organisation of work.

First, there has been the debate inspired by Braverman (1974) that has focused on deskilling and managerial control strategies. According to Braverman and like-minded writers (e.g. Zimbalist 1979), technology was important because it embodied a deskilling dynamic which changed the nature of people's jobs by narrowing work autonomies. The ideas and research of this period (1974–1983) can be said to constitute the labour process perspective of technology and work.

The latter half of the 1980s was marked by a radically different debate concerning the significance of technology. This perspective has been constructed around the notion of flexible specialisation (see Piore & Sabel 1984) and the transformation of work associated with new technologies and new managerial strategies. It was argued that current technology took on a different importance as an agency of upgrading and by shaping new forms of work organisation. These ideas had a broader set of origins than the writings of Piore and Sabel. For example, there is the so-called flexibility debate in Great Britain represented by the work of Atkinson (1984) and the flexible automation discussions in the USA represented by the work of Adler (1985) and Jaikumar (1986).

These two debates about technology and work are fascinating in themselves, but even more so in terms of the fact that they are diametrically opposed. However, the two perspectives (deskilling and flexible specialisation) also share common characteristics: both attempt to provide a simple narrative structure of events which defines central tendencies within capitalist industries. Prefiguring the conclusions of this monograph, it is argued that the attempt to achieve a simple narrative structure is based on a set of assumptions which cannot be sustained. In brief, the impact of technology on skills, employment levels and work organisation is often so sector specific that the sector level (service industry, manufacturing, etc.) may be the highest level of aggregation at which some of the broad trends can be identified.

This monograph begins by considering the deskilling debate, hypotheses concerning skill trends and the succession of interpretations over the years. It surveys the existing studies of skill trends and draws out the empirical conclusions. Section 2 focuses on what appears to be a simple question, but is in fact a complex issue: Where does technology come from? What are the sources of technology and the major theories of technological

change? In a curious way both the deskilling and flexible specialisation debates have ignored this central issue. Underlying this issue is the question of technological determinism versus strategic choice. I argue that this is a misconceived opposition.

Section 3 focuses on the flexible specialisation thesis and considers the variations on this theme and the conceptual problems embodied in it. It concludes by looking at alternative conceptualisations of the current period of restructuring.

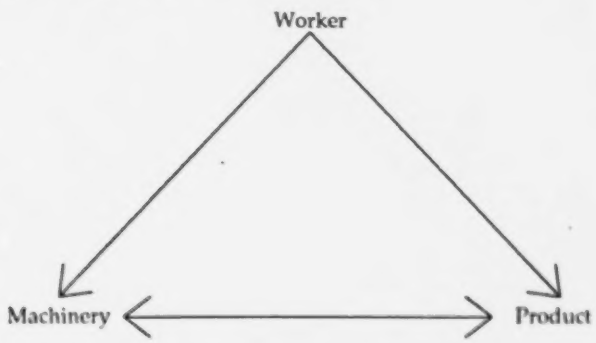
SECTION 1

THE DESKILLING DEBATE

Getting into the picture

There are many varied definitions of the term 'technology'. Indeed, it is impossible to construct a meaning of the term that satisfies all possible users. However, some operative conceptualisation is needed. Let us start with a simple triangle of relations involving worker, machinery as hardware and products (see Figure 1). It should be noted that, for the sake of simplicity, the following ideas are built up in terms of a manufacturing paradigm. However, they can be extended easily to the service sector.

Figure 1 A triangle of production relations

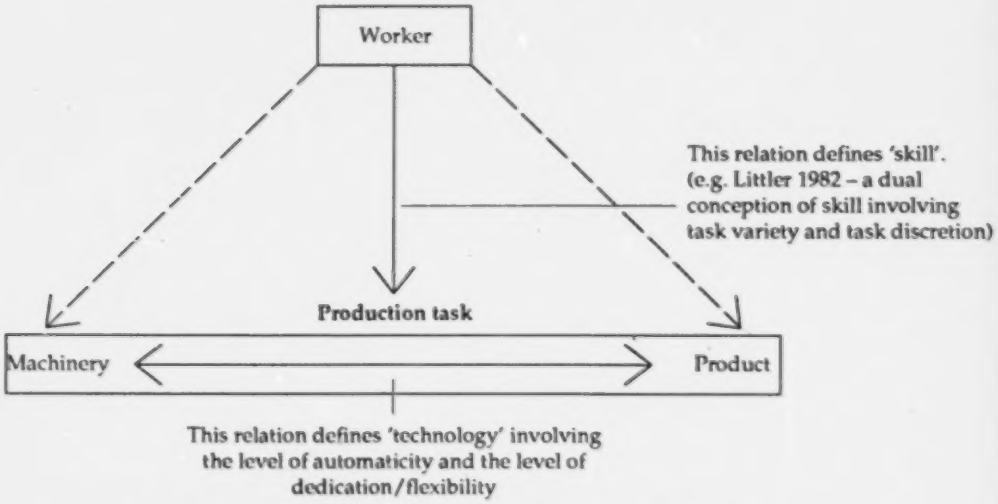


The worker has a certain form of involvement with the tools and machinery of the task situation (e.g. maintenance versus monitoring versus operation). Equally, the worker is faced with a certain degree of intervention (handling of the product and so on) involving a full product cycle or some fraction of it. The machine–product relation determines the level of the process that is under automatic control: it is, in part, the level of

automaticity. Another key aspect of this relation is the level of dedication. In other words, how flexible is the production process? Can it handle a variety of products? The economics of production are such that there exists a continual tension between cost minimisation and process flexibility (Kaplinsky 1984; Einzig 1957). Clearly, the machine–product relation will significantly affect worker–machine and worker–product relations.

The second step complicates matters a little more. It can be argued that the machine–product relation constitutes the basic nature of the *production task* as indicated in Figure 2. Moreover, the worker–production task interface is critical: it involves the worker–machine relation and the worker–product relation, but also the relation between the worker and the machine–product relation. In other words, what matters to the worker is the set of processes going on within the production context. This latter relation (as indicated in Figure 2) can be called 'skill'. The concept of skill is slippery and I will say more about it later, but it is important not to think of skill in a reified sense, but as a variable *relational* term. As such, the issue becomes how we usefully measure the worker–production task relation.

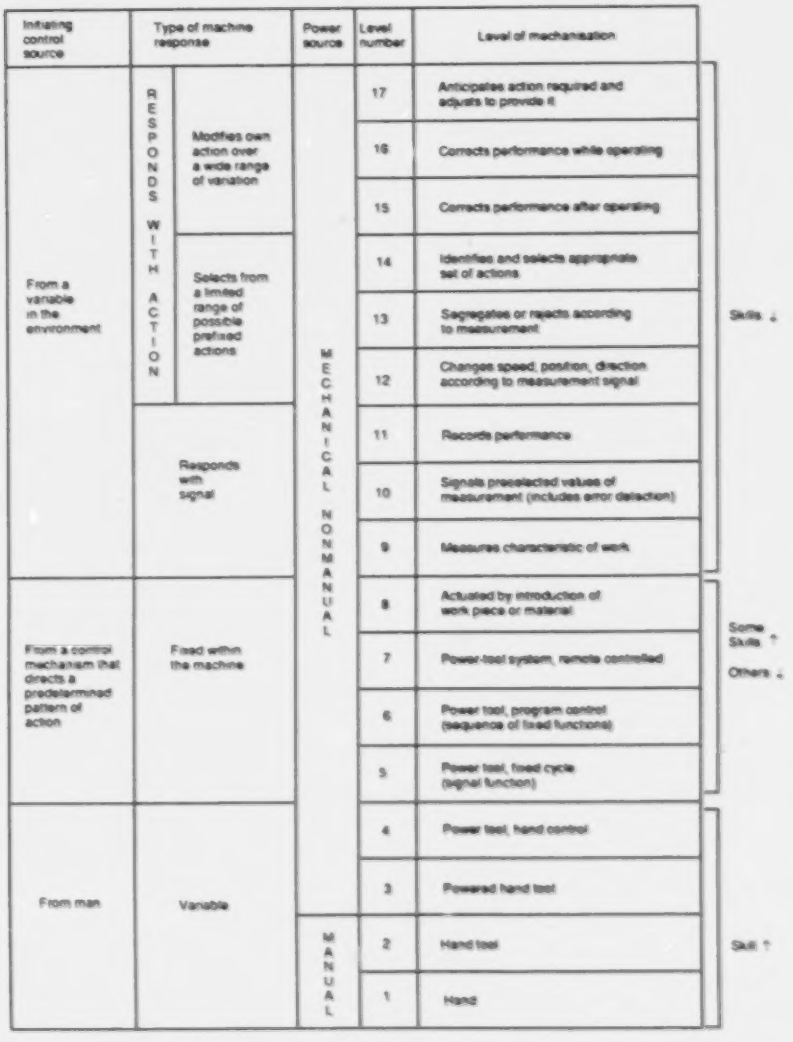
Figure 2 Skill and technology as relational concepts


Worker
This relation defines 'skill'. (e.g. Littler 1982 – a dual conception of skill involving task variety and task discretion)
Production task
Machinery
Product
This relation defines 'technology' involving the level of automaticity and the level of dedication/flexibility

In the first part of the twentieth century, technology was conceptualised as hardware (a set of machines and tools) or as hardware plus software (machines plus techniques and rules of effective use). During the 1960s, analysts in both the USA and Europe shifted their understanding of technology and suggested in effect that technology was also a relational concept. Writers such as Woodward (1970), argued that the machine–product relation and the characteristics of the overall production task were

the key elements in any understanding of technology. Similarly, Perrow (1970) argued that the degree of variability of the production process, plus the type of knowledge-base utilised, defined different production contexts.

Figure 3 Levels of mechanisation and their relation to power and control sources



Source: J. R. Bright, *Automation and Management*, Division of Research, Graduate School of Business Administration, Harvard University, 1958, p. 45.

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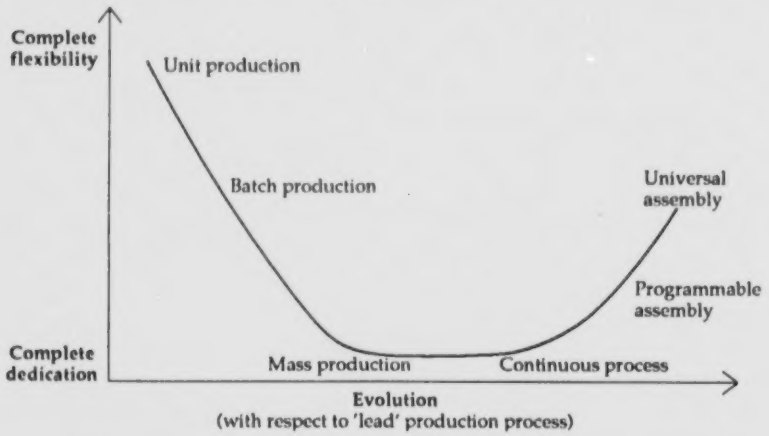
Other technology theorists tried to measure the various dimensions of 'technology'. For example, Bright (1958) tried to measure the level of automaticity by his well-known seventeen point scale (see Figure 3). This form of measurement was based on the type of machine response (column 2) and the initiating control source (column 1). At the upper level, according to Bright, the hardware involves not just corrective feedback processes (levels 15 and 16) but anticipatory action (level 17).

With this form of conception, it can readily be seen that technology can affect skill in many ways. It is suggested, as we will see, that as the level of automaticity increases the worker–production task relation changes, such that the level of intervention decreases and monitoring and maintenance functions become a more prominent part of the job. For example, Bright (1958) suggested that there are changes in the skill content of jobs as automaticity shifts levels (see Figure 3 and Reading 1, Appendix 1).

Figure 4 Technology: Level of dedication/flexibility

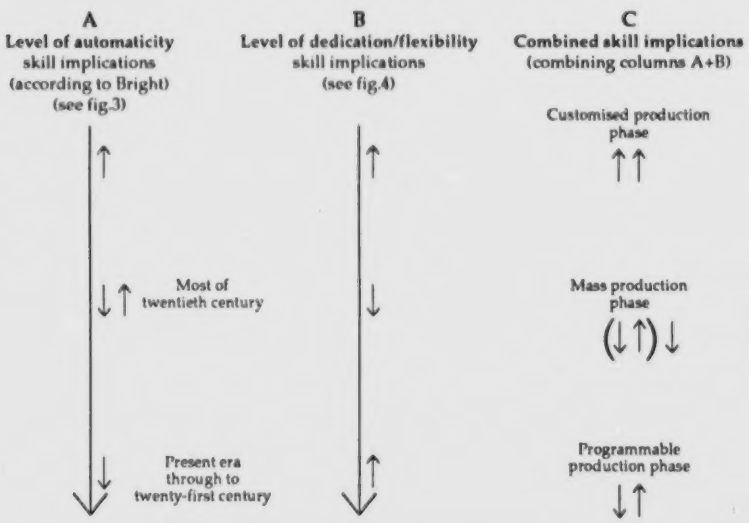


How does 'new technology' change the machine–product relation? New technology has worked in two opposing ways—it has involved an *increase* in the level of automaticity plus a *decrease* in the level of dedication (or increased flexibility). Figure 4 sets out, in a schematic way, the development of the leading edge production processes in relation to the dimension of dedication–flexibility. It is suggested that mass production (or 'Fordism') involved a highly dedicated production process, such that retooling for new products was extremely expensive. The machinery could not be reprogrammed, but had to be ripped out and scrapped whenever a new model was required. Even in the latter half of the 1980s car manufacturers were, typically, faced with a bill of US$300 million when rejigging a plant to produce a new model. The introduction of programmable and

reprogrammable technology is slowly changing these cost equations, whilst 'universal assembly' involves a loosely coupled system of reprogrammable work stations and reprogrammable feeders. The latter is a technology of the future, not a current technology.

What is important about the two dimensions of technology is that they have affected skills in two opposing ways and continue to do so. Following on from our previous analysis, Figure 5 sets out a rough calculus. It can be seen that Figure 5 brings together the level of automaticity which Bright proposed (Figure 3) and the level of dedication/flexibility (Figure 4) in terms of their hypothesised skill implications. These arguments then lead to the conclusion that there have been three phases of development—the customised production phase, the mass production phase (or Fordism) and, finally, the programmable production phase (column C). However, there are limitations to this form of argument.

Figure 5 Impact of changes in technology on skill according to some technology theorists



The next step in the development of the argument in the literature is twofold. First, it is suggested that the changes in the level of automaticity and the level of dedication/flexibility do not feed through to skill changes in a direct way. Rather, the changes are mediated by labour market structures and processes of skill formation, by industrial relations patterns and by managerial strategies. Second, it is suggested that phase thinking is too universalistic. In reality, there are significant variations between industrial sectors, economies and individual firms and these are likely to persist.

To ignore the weight of the first argument is to be labelled a 'technological determinist'. The technological determinism argument has been, in my view, overplayed. The basic means of providing mass produced goods in a competitive world system are more or less fixed, not by inescapable laws of technology but by the costs of redeveloping technology. There is no simple technological determinism, instead technology does permit a choice in relation to work organisation, job design and skill levels. Some writers have labelled the potentiality of choice a 'design space'—a variable area of manoeuvre in relation to any new technology. During the 1980s the OECD economies seemed to be in a phase of development where the technology was genuinely new—that is, it appears to be genuinely malleable and to offer a range of options. But the design space increasingly becomes closed off by a series of decisions and technological developments that in combination constitute sunk costs. Consequently, unwinding them—that is, making a series of different choices—becomes an impossible cost burden for any individual economy or firm. Nevertheless, it is important to recognise the existence of varying impacts and of a varying 'design space'.

The second argument is critically important. What is involved is a confusion over levels of analysis. Changes in technology and work content are usually industry or sector specific and cannot be readily universalised across the entire economy. Transformations in skill have two aspects: skill change may occur through changes in work content (the technical nature of the task structure) or through compositional effects (the creation or destruction of jobs of a specific skill level and changes in the distribution of people to those jobs).

If the preceding arguments are not clear, then an example may clarify them. If we consider the number of engineers in the US labour force, then:

> The number of engineers increased from 7,000 to 136,000 between 1880 and 1920. Stark argues that engineering underwent transformation from skilled, independent professionals and businessmen to employees of large firms with a narrowed skill range and less autonomy ... The content shift via incorporation of engineering inside the capitalist mode of production may well have been a downgrading of skill for the original 7,000 in 1880 compared with those that followed. The corresponding compositional shift in the growth of engineering was substantial and in the opposite direction because the skill level of engineering far exceeds the average for the labour force ... (Spenner 1983, p. 826)

If we move back from the preceding example to the general level, then it can be seen that the forces of change that promote skill upgrading or downgrading may act in contradictory ways. In sum, it is misleading to define a stage of capitalism on the basis of limited investigations of a specific number of labour processes. One strand of change does not constitute the whole fabric.

The problems of generalisation have not prevented a number of writers from attempting to construct hypotheses on long-term skill trends. Having achieved some basic grasp of skill and technology as concepts, the next subsection considers these various hypotheses.

Long-term skill trends

What are the different hypotheses concerning long-term skill trends? Broadly speaking there have been six basic hypotheses, which I will now consider.

The upgrading thesis

This view argues that with the development of industrialisation, the division of labour changes along the lines of greater efficiency. Technological change increases productivity and in so doing requires higher-than-average skills from the work force. Further, automation eliminates much putting-and-placing work and increases the overall levels of work complexity. These skill changes are associated with increases in educational and training levels and compositional changes in the occupational structure. In general, this upgrading view constitutes the optimistic view of technological change and impact.

The deskilling thesis

This view has a long history, but was promoted by Braverman in the mid-1970s and became a focus for labour process research for a decade. In essence, the thesis argues that work has been subjected to repeated processes of rationalisation and routinisation that reduce many workers to narrow task ranges with little autonomy. This process has been, and continues to be, experienced by widening circles of workers including white-collar and managerial workers. Clearly, this perspective has pessimistic overtones.

The Touraine hypothesis

This thesis suggests a wide-spread transition in the technology–skill link, resulting in a transition to flexible, multiskilled, supervisory, maintenance or monitoring job roles. This is discussed in more detail later, but is clearly an optimistic view of long-term trends.

The mixed-effects hypothesis

These mixed effects result from the simultaneous processes of deskilling and reskilling of the labour force. This complex two-way process amounts to little change in the overall picture. As Spenner (1983, p. 825) points out, this view is little more than a characterisation of empirical data rather than a well-developed theoretical position.

The agnostic position

It should be noted that a blanket 'agnostic' view has been put forward by Cutler (1978). According to him, it is only in relation to a given production context that one can talk about such terms as 'conception', 'execution' and 'skill'. The terms do not have the same meanings across different production processes in terms of which they are incommensurable (pp. 79, 84 & 86). If this is the case, then it is not possible to arrive at any definitive conclusions concerning long-term skill trends.

The social construction thesis

Various writers have argued that skill is a social construction. In other words, it is possible to label certain work activities as skilled whatever the technical content (Littler 1982, p. 9). It is barriers to entry which prevent skill dilution and permit the continuance of skill status. The printers are often cited as a classic case of this process (e.g. see Hill & Gidlow 1988). Recent literature has emphasised the social construction thesis in terms of gender: 'skill' is a status which has been gender determined and women's work regularly fails to qualify as skilled. As Hill and Gidlow put it:

> The sense of being a skilled worker is a social construct, based not simply on current job content and on the techniques and work habits learned during apprenticeship, but also on sets of cultural assumptions. These arise particularly, though not exclusively, from gender-defined socialisation and the gender stereotyping of occupations. (Hill & Gidlow 1988, p. 82)

On this interpretation, skill is socially constructed, gender specific and weakly related to the technical content of work.

The dominant paradigm of long-term skill trends has changed over time. There have been a succession of interpretations concerning the broad patterns of skill requirements associated with new technologies. This central issue has swung back and forth across the academic generations.

In the 1950s and 1960s the research on automation, computerisation and work organisation was dominated by theorists like Woodward (1970),

Blauner (1964), Touraine (1962) and Mallet (1975), all of whom tended to see automation leading to a recomposition of jobs and an upgrading of skills relative to the limited job requirements of assembly line production. Touraine, for example, produced a phase theory of the evolution of work organisation and skills. Put simply, he distinguished between the technical aspects of work and the social aspects. The second step in the argument is to postulate three phases of development. Phase A is the craft period, with an emphasis on the technical aspects of work, job autonomy and pride in expertise. Phase B is a period of mechanisation (or even, according to Touraine, a period of 'transition' —a rather teleological idea) with increasing amounts of unskilled work. Phase C is the period of automation, where the person–product relation is most attentuated. The worker no longer actively intervenes in the production process; she or he monitors, inspects and controls. As a consequence, the social aspects of the work become predominant. Touraine's work is worth discussion because it still underlies a lot of recent writing. Abernathy (1978), for example, produced a very similar analysis and periodisation in connection with the automobile industry (see p. 105), whilst Adler's recent work also echoes Touraine (compare with Figure 5).

The late 1960s and the 1970s resulted in a very different perspective—a switch from optimism to pessimism concerning the outcome of automation and technological change. A series of studies, originating in different countries, expressed a striking convergence of view that automation's effects on the work organisation and skill patterns would be detrimental because the mode of deployment of technology was a reflection of its social context, particularly property relations. Writers such as Braverman (USA), Freyssenet (1974) in France, Beynon and Nichols (1977) in Great Britain (though their work was later influenced by Braverman, it predated him), Kern and Schumann in West Germany and Panzieri in Italy, all argued various versions of a general thesis—namely, capitalist societies reflecting intrinsic economic forces would tend to deskill work in the constant search for lower production costs and greater control over the production process. Later analyses distinguished between these strategic managerial objectives: it was argued that in those industries dominated by one or a few firms, where price competitive markets were limited, the desire for worker control may have been the stronger managerial motive. In those industries characterised by large numbers of price competitive firms, the need to reduce costs would have been paramount.

This 1970s pessimism was based on a rejection of technological determinism. According to this view, technology did not determine work organisational outcomes rather, these were determined by economic configurations and by patterns of worker resistance. However, there was an inadequate attempt to grasp the essence and nature of technology during this period. The 1970s perspective was also based on a different compara-

tive base. Unlike the 1950s and 1960s, the skill comparison was not with the assembly line, but with traditional forms of craft working. Such a comparison was both implicit and explicit in, for example, Braverman's work.

The 1970s framework based around a deskilling paradigm spawned a mass of research, case studies and historical studies exemplifying, exploring and illustrating the notion of deskilling. This was also true of the progress of research in Australia and New Zealand, though with a time lag. Indeed, much of the Australian and New Zealand work has been locked into a limited deskilling paradigm (e.g. see the special issue of the *New Zealand Journal of Industrial Relations*, 1984). However, few of these deskilling studies broaden the focus to make wide-ranging statistical comparisons, partly because of the difficulties of defining 'skill' across occupations and across technological contexts (compare with the 'agnostic' position). As we will see, this focus of the Australian and New Zealand research contrasts to some degree with the work that has been conducted in the USA (see Spenner 1983).

The limitations of the deskilling paradigm were revealed in other ways. One problem rapidly became apparent—that is, if one takes a simplistic linear and unrealistic thesis and concludes, on the basis of case study research, that it is simplistic, then the theoretical gains are few and, moreover, are increasingly diminishing.

In the 1980s, a change of emphasis and tone became apparent. The change of tone approximates more to the 'optimistic' pole as can be seen from the work of Piore and Sabel (1984) and Kern and Schumann (1984). In essence, the paradigm is one of soft technological determinism and of a broad tendency toward skill upgrading. This perspective assumes the continued force of capitalist competition (firms seeking out the most productive combinations of machine and human capacities) but is in fact a process in which the outcome is more often than not an upgrading of worker skill requirements. Part of the reason is that using automation, especially modern forms of technology, as a means of deskilling and introducing low-quality labour can result in inflexibility, thus denying the full potentiality of the technology over time (see Hirschorn 1983; Abernathy, Clark & Kantrow 1983; Piore & Sabel 1984). The post-Fordist theorists see a higher level of skill and greater control over the immediate labour process by workers and argue that these features are intrinsic to flexible specialisation.

In connection with the flexible specialisation thesis and skill, Adler gets closest to reinstating the perspective of the 1950s and the early 1960s. He argues:

> By creating a continuity in the production process at a higher level, programmable, flexible automation is the form whereby the

> 'chemicalization'—the movement by which more and more segments of manufacturing would come to resemble the chemical refinery—that was predicted by Naville in 1963 is coming to fruition. (Adler 1985, p. 28)

This is a strong view, not shared by all writers. Nevertheless, it indicates the renewed optimism of the 1980s concerning technology and skill, despite the enormous levels of unemployment and underutilised capacity in many economies. This optimism underlies the post-Fordist, post-modernist or 'new industrial era' debates. Flexibility is associated with multiskilling and multiskilling is *not* the same outcome as deskilling. These issues of the flexible specialisation thesis and skill are discussed in Section 3.

So far, we have examined some basic notions of skill and technology and considered the various hypotheses concerning long-term skill trends. These hypotheses have been linked to different periods of research and analysis. The next step is to shift from general hypotheses to examine the available data.

From hypotheses to data

The deskilling debate has not led to definitive results in relation to skilled work and technological change. The best available data are from the USA and the major US studies on skill are set out in Table 1. The studies which are listed are based on large national samples of people (e.g. see Mueller et al. 1969) or of jobs, utilising the US Department of Labor's *Dictionary of Occupational Titles*. The main outcomes of these studies are listed in column 6 of Table 1. Most of the studies show little net change or a small upgrading effect. Nevertheless, there are three major problems in reaching a clear verdict in the deskilling debate:

1 There are at least two tracks of change—work content and compositional shifts. We have already met these ideas. The major point here is that the two tracks may be moving in opposite directions, so that localised studies of work contexts may not capture the overall offsetting compositional effects.

2 Associated with (1) is the fact that empirical studies have adopted two different approaches:

   a aggregate studies that focus on the macro or societal level of analysis; and

   b case studies based on specific firms, industries or sectors, (e.g. printing or banking) (see also the 'Annotated Bibliography').

These two approaches have varying methodological strengths and weaknesses and tend to reach different conclusions (see Spenner 1983, p. 825). Aggregate studies have tended to yield upgrading results, whilst case studies have been more prominent in the deskilling literature. For example, Zimbalist's work (1979) consists of a series of case studies and emphasises a deskilling dynamic across a range of industries. However, his work lacks systematic consideration of the compositional changes which can result in misleading generalisations. Equally, aggregate studies average out forms of change such that if the meaning of 'skill' varies between firms (a view endorsed by the social construction thesis and the agnostic position) then these variations will not be detected. Consequently, case studies of industries or sectors may provide the greatest insights into the mechanics of the transformation of skill (see Littler 1982, p. 141).

3 The notion of skill is slippery and our conceptualisation and measurement of skill is poor. In general, as we have seen, there is a dual conception of skill. In other words, it involves at least two fundamental dimensions:

a skill as a task variety or complexity; and

b skill as task discretion (or autonomy/control).

These two dimensions are reflected in Table 1. The existence of these two meanings of 'skill' gives rise to the possibility of divergent aggregate trends.

Before we try to summarise the skill trends in more detail, it is worthwhile looking at the limited Australian data. Virtually all of the Australian material is in the form of case studies (see the 'Annotated Bibliography'). The largest Australian survey which has been carried out focused on skilled workers—a sample of one thousand seven hundred trades workers in New South Wales (Davis 1988). The study was based on the workers' subjective assessments of changes in the knowledge requirements and skill requirements of their jobs in relation to technological change. The research work generated three main results from our point of view:

1 There was no perceived effect of technological change during their work lifetime for a large proportion of trades workers (40 per cent – 50 per cent) in terms of skill and knowledge requirements. This was because no significant technological changes had occurred, or because the changes had not affected the nature and exercise of skill.

2 There were more upgrading than deskilling effects in the occupations and areas affected, with more impact on knowledge than on skill requirements.

3 There was a highly differentiated effect according to trades and

industries (metalworking, woodworking, automotive trades and electrical fitting–mechanics trades). Deskilling effects were most marked for carpenters and joiners in the building industry (see Davis 1988, p. 51).

In general, Davis suggests that there is a complex relationship between technological change, skill and the nature of the labour process. In particular, any deskilling dynamic may be checked by intrinsic factors within capitalist-type production systems—namely, competition based on quality as well as cost minimisation increases the need for the utilisation of work force skills by employers (Davis 1988, pp. 47–8 & 53). This argument is a common one in the flexible specialisation literature as we shall see in Section 3.

The Australian data from Davis is useful as it reinforces much of the US literature as surveyed by Spenner (1983). If we try to summarise the complex and ambiguous results of the empirical research in this area in the light of the long-term skill hypotheses, then we are left with four conclusions and one question:

1 There is little evidence of universal and monolithic change in the task content of jobs with respect to task complexity since 1945. This conclusion is supported by both the US literature and Davis's survey. If anything, there has been a minor amount of upgrading.

2 In connection with compositional changes in skill (understood as task complexity), there appears to have been nil effects since 1945 and maybe since the 1900s. However, this conclusion relies on a key assumption—namely, constant work content in relation to specific occupations over the entire period. This is a difficult assumption to make and undermines the strength of this conclusion.

3 In relation to the second meaning of 'skill' (skill as task discretion or autonomy–control), the evidence on aggregate content changes is ambiguous.

4 Spenner concludes that:

> The dominant impression from these studies is one of approximate aggregate stability. Yet virtually all of the aggregate studies show upgrading and downgrading occurring within sectors or subgroups of the population. Further, case studies document substantial upgrading and downgrading in regions of the sample space. If the pattern is accurate, what is its sociological significance? Are there social or institutional forces that contribute to the apparent aggregate equilibrium in the face of forces that generate change in different directions within sectors? (Spenner 1983, p. 834)

The preceding question has not received a satisfactory answer. It is possible that aggregate stability over time masks clusters of sectoral changes

Table 1 Major US studies of skill trends

Study	Sample/ Population	Time period	Work content/ Composition shift	Skill measures	Outcomes	Limitations of Survey Design
Horowitz & Herrnstadt (1966)	All DOT jobs in five industries (slaughter and meat packing, rubber tyres and tubes, machine shop trades, medical services, banking)	1949–1965	Content	For jobs; 25 DOT indicators; most indicators reflect skill as substantive complexity; 2 or 3 indicators may approximate skill as autonomy–control	Mixture of upgrading and downgrading; little net change	Limited to five industries; depends on independence of DOT editions
Spenner (1979)	5% sample of 4th edition DOT titles (N=622) matched to 3rd edition titles	1965–1977	Content	For jobs, DOT indicators for data, people and things; skill as substantive complexity	Small upgrading; little net change	Depends on independence of DOT editions
Berg (1970)	1950–1960 decennial census distributions; 4000 DOT jobs rated in 1956 and 1965	1950–1960 (1956–1965)	Composition and content	For jobs: DOT General Educational Development (GED) indicator: skill as substantive complexity	Small compositional upgrading for content, 54% of jobs had the same GED, 31% were higher and 15% were lower; apparent content upgrading	Depends on independence of editions, possible validity problems with GED; change in GED categories between editions may overestimate upgrading
Berg et al. (1978)	1950–1970 decennial census distributions; 2nd edition DOT estimates for 1950; 3rd edition estimated for 1960 and 1970	1950–1970 (1956–1965)	Composition and content	For jobs: DOT GED indicator; skill as substantive complexity	Same as Berg (1970) for 1950–1960; small compositional upgrading for 1960–1970	Same as Berg (1970)
Rumberger (1981)	1960 and 1976 census and CPS respectively: employed population 14 and older; 3rd and 4th edition DOT	1960–1976 (1965–1977)	Composition and content	For jobs: DOT GED indicator; skill as substantive complexity	Modest compositional upgrading; small content upgrading but with some evidence of proletarianisation as the number of very highest skill jobs declined	Depends on independence of DOT editions, possible validity problems with GED
Rumberger (1981: Table 4) also see Eckaus (1964) and Rawlins & Ulman (1974)	See Rumberger above; 1940–1950 decennial census distributions	1940–1976	Composition	For jobs, DOT GED indicator; skill as substantive complexity	Overall 18% compositional upgrading over 36 years, greatest increase between 1950 and 1960	Depends on independence of DOT editions; possible validity problems with GED
Reanalysis of Dubnoff (1978) data, see Spenner (1982)	Decennial census distributions for all gainful workers (1900–1930) or all employed workers (1940–1970)	1900–1970	Composition	For jobs: DOT indicators for data, people things, SVP and combination of the first three indicators; skill as substantive complexity	Little net change; only 1 of 18 skill-year or higher order effects significant in loglinear decomposition; for one interaction, evidence of skill polarisation in recent years	Depends on the quality of the map of detailed occupations from one census year to another; comparison assumes constant work content to 3rd edition DOT scores over entire time period

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Mueller et al (1969)	National probability sample of 1967 labor force (N=2662)	1962–1967 (retrospective measure of job and machine change over 5 years)	Content (composition inasmuch as 1967 sample members changed jobs)	For people; detailed reports of level and type of machinery use over five years, self reports of 'skill required' and 'own influence' in organising the work, mixture of skill as substantive complexity and skill as autonomy-control	For job changers over 5 years, modest upgrading in mechanisation level and skill measures; for those who stayed in the same job but experienced machine change: (percent) more same less 'skill' 53 36 7 'influence' 34 54 7 Across all respondents, small upgrading	For job changers, conflation of compositional upgrading with seniority-career effects; short time interval; validity-reliability of self-report and retrospective report data; compositional shift via demographic replacement ignored
Karasek et al (1982)	National samples for 1969, 1972, and 1977, adult employed labor force working 20 or more hours per week, (N=4531)	1969–1977	Content (composition partially adjusted for with demographic controls, otherwise assumed constant)	For people, aggregated to 240 occupation categories, four replicated questions combined into single scale (learn new things, 'skill', creativity, and repetition); skill as substantive complexity	No change in skill discretion scale scores	Validity-reliability of self-reports; slightly different response categories in 1977 compared with 1969 and 1972
Wright & Singelmann (1982)	Decennial census distributions for 37 industry sectors, the design decomposes 1960–1970 shifts into industry, class, and interaction component, skill levels implicit in class categories	1960–1970	Composition (industry and class shifts)	For people; measured through class categories (self-employed, have employees, have subordinates, and level of freedom and decision making in jobs); self-reports taken from 1969 National Survey of Working conditions; skill as autonomy-control	Overall small changes; mixed evidence for upgrading and downgrading in class and industry shifts; for upgrading more managers, for downgrading more workers, industry and class composition shifts tend to operate in opposite directions, some evidence for proletarianisation in the class composition shift into the working class	Depends on the validity of class measurements, validity-reliability of self-report; possible skill heterogeneity in class and industry categories, assumes constant work content over the time interval; skill is measured indirectly in class categories
Sobel (1982)	National samples for 1970, 1973, 1976 and 1977, adult employed labor force working 20 or more hours per week	1970–1977	Composition and content	For people; related questions in successive surveys taken to measure supervisory status; skill as autonomy-control	Decline in skill, percent classified as supervisors: 1970 36.1% 1973 34.1% 1976 31.4% 1977 31.1%	Different sampling designs at the time points, non-identical questions to measure supervisory status at the time points, validity-reliability of self-reports, indirect measure of skill

Notes: 1 DOT refers to the *Dictionary of Occupational Titles* published by the US Department of Labor. It was published in 1949, 1965 and 1977. Each issue contarins 12,000–13,000 job titles related to a wide range of measures of skill and work conditions. These can be mapped onto census data.

2 GED refers to 'general educational development' and is one of the set of measures used in DOT. GED includes mathematical, language and reasoning development required

3 SVP refers to 'specific vocational preparation' and measures the total training time for an average performance at a specific job.

Source: Based on K.I. Spenner, 'Deciphering Prometheus: Temporal changes in the skill level of work', *American Sociological Review*, vol. 48, no. 6, 1983, pp. 832–3.

at different periods. For example, it might be the case that the period from 1914 to the 1940s (the key period of Taylorism) entailed more deskilling in manufacturing than upgrading. The period of the 1940s to the 1990s has perhaps involved marginally more upgrading than deskilling in manufacturing, whilst the service sector has faced an extensive range of occupational changes during this period which, because of sectoral lag effects, are more akin to the changes in manufacturing during the early period of the twentieth century. (This argument is taken up again in the 'Conclusion').

If the data on long-term skill changes are so ambiguous, then why has so much been made of circumscribed case studies and limited statistics? The answer lies perhaps in 'tea-leaf social analysis'. Dramatic processes of change in certain occupations (e.g. printers) or certain industries (e.g. robotics in the automotive industry) are interpreted as indicators of the future. They take on a symbolic significance leading people to believe, and act, as though the future of work involves a simple dynamic or that the workerless factory is just around the corner.

In Section 2 we return to the notion of technology and interrogate the various meanings of the term.

SECTION 2

WHERE DOES TECHNOLOGY COME FROM?

As I have indicated this is a simple question but a complex issue. The complexity of the issue partly lies in the fact that 'technology' as a concept is peculiar (though certainly not unique): it means different things at different levels of analysis. At the macro level, it means the social institutions surrounding invention and innovation. It does not mean this within the plant. At the micro level, it means what I have indicated in Section 1—the complex of relations between machines and products. To what extent is technology, in a macro sense, an independent variable? If it is an independent force for change, then what are the sources of technology? Different writers have responded to these questions with a spectrum of answers varying from the exogenous (independent) technology-push answers to a market-driven or need-pull model of invention and innovation.

The traditional understanding of the invention–innovation relation was based on the image of the isolated genius. As Burns and Stalker put it: 'In nineteenth-century Britain the archetypal formula for the process of innovation was enshrined in the fantasy of Watt and the kettle (Burns & Stalker 1961, p. 24). Such images ignored the critically important role of social and personal networks, particularly the nineteenth-century scientific clubs and associations. Urbanisation was associated with a spreading literacy which encouraged the development of these clubs and institutes. Thus the cultural links, between knowledge of laboratory demonstration, knowledge of manufacturing operations and knowledge of existing or possible demand for goods or services were widely spread. This period of invention and innovation was associated with small firms and a ready supply of venture capital. Technological change occurred largely through the birth and death of firms, a simple and drastic form of institutional change.

By the end of the nineteenth century, technology had advanced to the point where several developments had taken place:

1 It was the end of the period when a network of personal relationships provided an adequate scale of communication for invention and

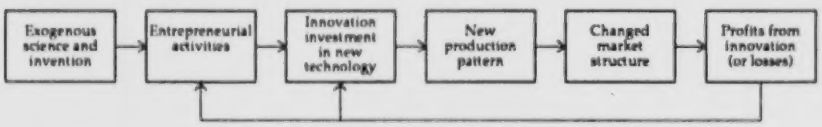
innovation. More extensive patterns of communication were required.

2 Science and industry had become distinct social systems, entered by different routes and with limited linkages whereby people or information could pass between them. Most scientists had become salaried professionals.

3 A need for 'linking' institutions was apparent, but no clear forms existed. Edison's Menlo Park Laboratory, established in 1870, was perhaps the first example of an attempted organisational innovation in this area. It employed one hundred workers and was independent of both industry and the established scientific institutions.

It was Schumpeter (1943) who tried to put the changes of the nineteenth century into a general form and to suggest that the critical social innovation of the twentieth century was the captive, industrial research and development laboratory. Such research and development laboratories were emerging in the newer industries (e.g. chemicals and electrical products). Schumpeter suggested two contrasting models of innovation and his first model of entrepreneurial innovation is indicated in Figure 6.

Figure 6 Schumpeter's model of entrepreneurial innovation



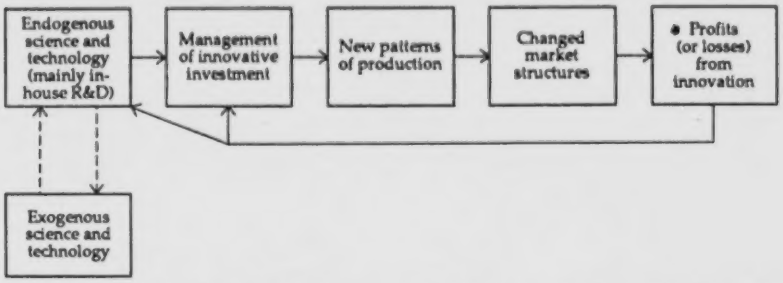
Source: V. Walsh, J.A. Townsend & C. Freeman, Trends in Invention and Innovation in the Chemical Industry, Science Policy Research Unit, University of Sussex, Brighton, 1979.

Figure 6 suggests that exceptionally creative entrepreneurs, deriving ideas from an exogenous science, undertook risky innovative developments to launch new products and change existing market structures. They often anticipated, rather than followed, demand. This still allows for a feedback loop, as the profits from innovations reinforced the direction of investment, or the losses changed the pattern of investment.

Schumpeter suggested that endogenous science and technology, mainly within the research and development laboratories of large corporations, increasingly substituted for the mechanisms of the 'exogenous' inventor setting up in business on his or her own. However, the possibility of mechanisms akin to those shown in Figure 6 continuing to operate alongside large-scale corporate research and development was not ruled out. Schumpeter's model of corporate, managed innovation is indicated in Figure 7. The key idea here is that 'technology' is now less of a random process and more of a managed process of innovation. Discretionary

research or curiosity-led research gave way to technological planning activities. In part, this occurs because the development of modern, large corporations permits the development of a strategic function and business strategies for the first time.

Figure 7 Schumpeter's model of large firm managed innovation


Endogenous science and technology (mainly in-house R&D)
Management of innovative investment
New patterns of production
Changed market structures
Profits (or losses) from innovation
Exogenous science and technology

Source: V. Walsh, J.A. Townsend & C. Freeman, Trends in Invention and Innovation in the Chemical Industry, Science Policy Research Unit, University of Sussex, Brighton, 1979.

There are two other models of the innovative process that are radically different. Schmookler's (1966) work, using detailed time series data, concluded that market growth and market potential were the main determinants of the rate and direction of inventive activity. He argued that Schumpeter's views were not tenable and that:

> the belief that invention, or the production of technology generally, is in most instances essentially a noneconomic activity is false ... the production of inventions and much other technological knowledge, whether routinized or not ... is in most instances as much an economic activity as is the production of bread. (Schmookler 1966, p. 208)

This idea is the 'need-pull' model of innovation and is summarised in Figure 8.

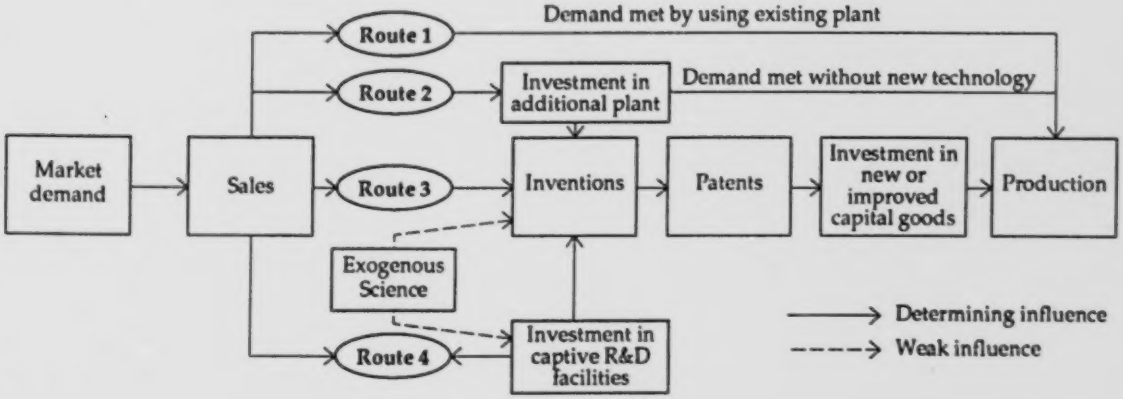
It can be seen from Figure 8 that the starting point is the market which impacts on sales figures. This impact can result in four possible management strategies:

1 route 1 constitutes the least innovative response—production is increased by using the existing plant more efficiently;

2 route 2 involves increased production by building a new production line or a new factory alongside the old one without new technology;

3 route 3 entails a strategic response in terms of a new process or product innovations, perhaps drawing on exogenous science as indicated, in the same way that one draws on a sperm bank, but the market remains the determining force; and

Figure 8 Figure 8 Schmookler's model of demand-led invention



Source: V. Walsh, J.A. Townsend & C. Freeman, Trends in Invention and Innovation in the Chemical Industry, Science Policy Research Unit, University of Sussex, Brighton, 1979

4 the market also remains the determining force in Route 4 which incorporates Schumpeter's ideas of captive research and development facilities.

An even stronger version of the need-pull view of innovation is that of Hessen (1931), who argued for a highly deterministic theory of market demand shaping not only technology but also basic science. This model is summarised in Figure 9.

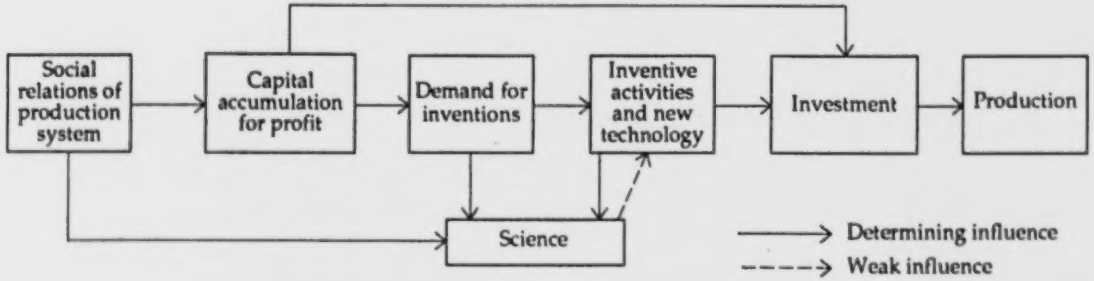
It can be seen that the social relations of production, the basic power relations in society, shape both the nature of science and the nature of new technologies. According to this model, technology cannot be an exogenous force for change. Instead technological innovation is subject to the monopolising and 'cream skimming' strategies of large corporations. For example, General Motors popularised private automobiles in the 1920s and 1930s by buying up public transit systems and closing them down or by de-electrification (see DuBoff & Herman 1981, p. 108). On the basis of this model, 'technology' is the wrong set of variables to be examining if we wish to understand the development of modern management.

The systematic evidence and reworking of time series indicates that none of the preceding models are universally correct (e.g. Walsh et al. unpub.). Instead, the relation among science, technology and the market is rarely unidirectional or simple. There appear to be periods when technology leads and technological advances largely determine the scientific agenda; periods when technology 'feeds on itself' creating an intrinsic dynamic without any major influence from basic science and periods when, in contrast, science leads and technology is clearly derivative. Moreover, the directions of influence can vary among different sectors of industry.

If we conclude that technology, at a general level, cannot be subsumed under the umbrella of market forces but does have a degree of independence, then the question still remains: What creates an independent dynamic for technology? The answer lies in military spending. Much research and development, especially in the USA and Great Britain, has been for military purposes. Most science and technology is militarily driven. For example, I have pointed out elsewhere that the diffusion of mass production was stimulated by its military significance. Mass production methods were seen as a precondition of military success in the 1930s and 1940s: the ability to mass produce cars was the ability to mass produce tanks (Littler 1985, p. 18). By the end of the 1980s, the USA was spending $4 billion per year on creating robotic tanks, planes and submarines. This research and development will create the next level of robotics utilising artificial intelligence and will feed through to manufacturing industry and the service sector.

Militarily driven research and development has unintended consequences. Invention and innovation are not mirrors of the image of societal power relations, but they can carry a random or independent influence on the nature and direction of organisational change and work content.

Figure 9 Hessen's model of demand-led technology and science

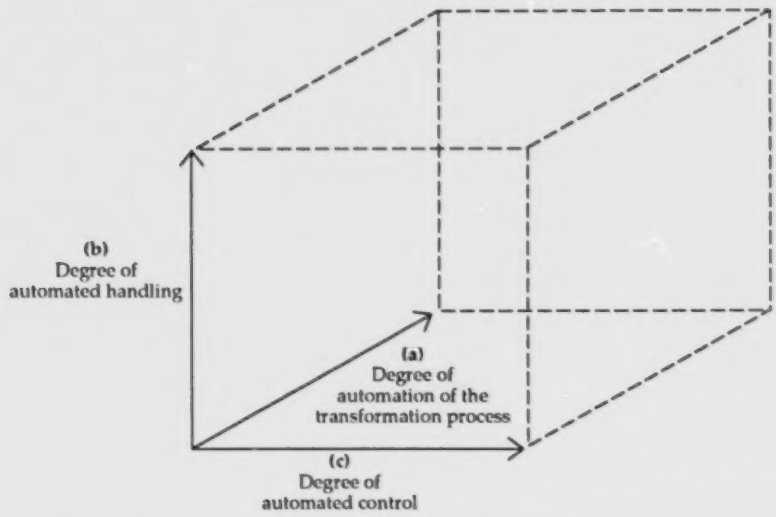


Source: V. Walsh, J.A. Townsend & C. Freeman, Trends in Invention and Innovation in the Chemical Industry, Science Policy Research Unit, University of Sussex, Brighton, 1979.

So far, we have examined 'technology' as a societal concept and concluded that there is a technology-push (partly militarily based) as well as a demand-pull in connection with technological change. However, what are the major theories of phases of development in relation to technology, particularly in connection with work organisation? How are we to understand the concrete processes of technological change?

One answer is to see automation as a three-dimensional space following the work of Bell (1972) and Blackburn et al. (1985) (see Figure 10).

Figure 10 Automation as a three-dimensional space



Source: R.M. Bell, *Changing Technology and Manpower Requirements in the Engineering Industry*, Sussex University Press, London, 1972, p. 65.

The argument underlying Figure 10 is that all production processes consist of three different functional activities:

1 the transformation of work pieces (e.g. the shaping, cutting, drilling of metal, wood, etc.);

2 the transfer of work pieces between work stations; and

3 the coordination and control of (1) and (2).

These three activities can be mechanised or manual and a high level of automation in one area does not necessarily imply a high level in the other two. Moreover, they are not just analytic distinctions, because it is further suggested that there have been three phases of mechanisation which have been the successively dominant form over the past century across most industries. The first of these phases (primary mechanisation) ran from the

middle to the end of the nineteenth century and placed the emphasis on using power-driven decentralised machinery to accomplish transformation tasks. The second phase (secondary mechanisation) ran from roughly the start of World War I to the 1950s, and placed the emphasis on using machinery to accomplish transfer tasks. The third phase (tertiary mechanisation), which began during World War 2 and is still continuing, has placed the emphasis on using machines to achieve control functions. Given these ideas, it is possible to outline an 'engineering model' of change which focuses on the metal-working industries. Thus Table 2 sketches such a model of development. (It should be noted that the (a), (b), (c) at the top of the columns of Table 2 correlate to the dimensions in Figure 10.)

There is one key question implicit in Table 2: What drives the shift from one form of mechanisation to another? The shift from one predominant mode of mechanisation to another is associated with 'bottlenecks' and with diminishing returns in relation to existing paths of development. In other words, the 'bottlenecks' are not simply technological problems but profit problems. Thus, the rapid increase in the productivity of late nineteenth-century machine tools resulted in increasing levels of competition and declining profit opportunities until new process or product technologies were brought on stream. In the event, the major innovations centred around the automation of transfer systems as well as new products. The secondary phase of mechanisation, typified by assembly line methods and Fordism, solved some of the problems of synchronisation and production imbalances by mechanical handling technologies, and in so doing created competitive advantages for firms like Ford. These technologies created the mass production industries which, however, faced a restricted diffusion potential because of variations and fluctuations in many product markets, making dedicated automation impossibly expensive. Thus, a new bottleneck arose from the problems of extending assembly line production beyond the mass production industries without the control innovations which permitted flexibility. However, this only mattered when profit levels were declining, as they did in the 1970s. It is in this context that we should examine information technology or the so-called 'new technology'.

In terms of what has been said previously concerning the basis for research and development expenditure, there is an expanded understanding of Table 2 which needs to be spelt out—that is, the shift from one form of automation to another is determined by systematic changes in profit opportunities (as has been said) but *also* by extensive changes in military imperatives. It was World War 1 and World War 2 that significantly affected the move toward secondary forms of automation. Similarly, it was the Cold War which fuelled the research and development expenditure for the diffusion of tertiary forms of automation. To put it crudely, in terms of hardware Table 2 indicates the shift from Winchester rifles to tanks to radar arrays controlling missile deployments.

Table 2 Engineering model of evolution of production processes

	(a) Primary mechanisation	(b) Secondary mechanisation	(c) Tertiary mechanisation
1850			
	beginning		
1875			
1900	spreading across sectors and maturing technically	beginning	
1925			
1950	continuing but increasingly likely to occur together with secondary or tertiary mechanisation	significant diffusion and increasing technical maturity Further diffusion restricted by product markets	beginning in some industries and slowly becoming more flexible
1975			flexibility increasing

Source: P. Blackburn, R. Coombs & K. Green, *Technology, Economic Growth and the Labour Process*, Macmillan, Basingstoke, 1985, p. 87.

Table 2 is based on the work of Blackburn et al. and similar arguments are pursued by Kaplinsky (1984). He suggests that there are basically three spheres of production—design, information coordination and manufacturing. Within each of these spheres there are distinct types of activity (e.g. within the manufacturing sphere there are significant differences between handling, forming, assembling, storage and distribution). Within the coordination sphere, information has to be gathered, processed and stored. Given these three spheres of production, each with its particular set of activities, it is possible to distinguish between three different types of automation:

1 *Intra-activity automation* where a discrete operation is independently automated (e.g. tool changing).

2 *Intrasphere automation* which involves the linking of different activities within the same sphere (e.g. the linking of machine tools through computer control (DNC)).

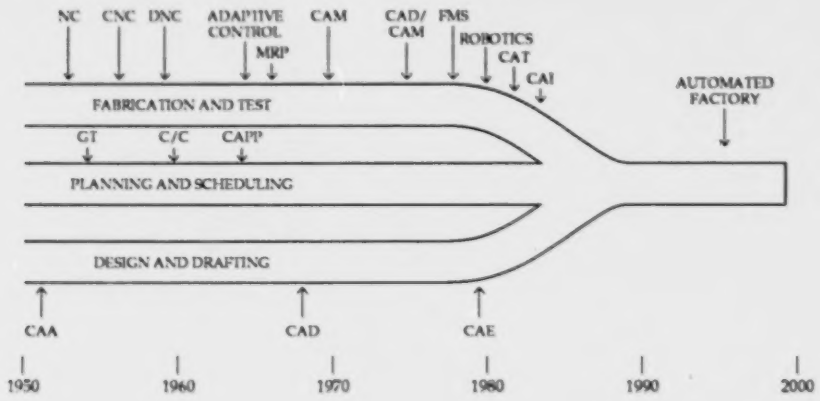
3 *Intersphere automation* which involves the linkage of different elements of the three spheres. This is clearly the most extensive form of automation.

The comprehensive form of automation (3), is defined as *advanced manufacturing technology* moving toward the automated factory of the future.

Other engineering industry analysts have also adopted an evolution-

ary perspective in order to make sense of new technology. For example, Mitchell sees the new process technologies of design (CAD), planning and scheduling (CAPP) and manufacturing (CAM, FMS) on parallel pathways converging toward a total unified system—the automated factory—at about the turn of this century (see Figure 11). Such integration, it is suggested, will enable management to gain control over the entire process of manufacturing.

Figure 11 Mitchell's vision of the evolution of the automatic factory



Source: J. D. Mitchell, 'Computer integrated manufacturing—An evolutionary perspective', *Proceeding of Computer-Aided Production Management Conference*, Institute of Production Engineers, London, 1984, p.4.

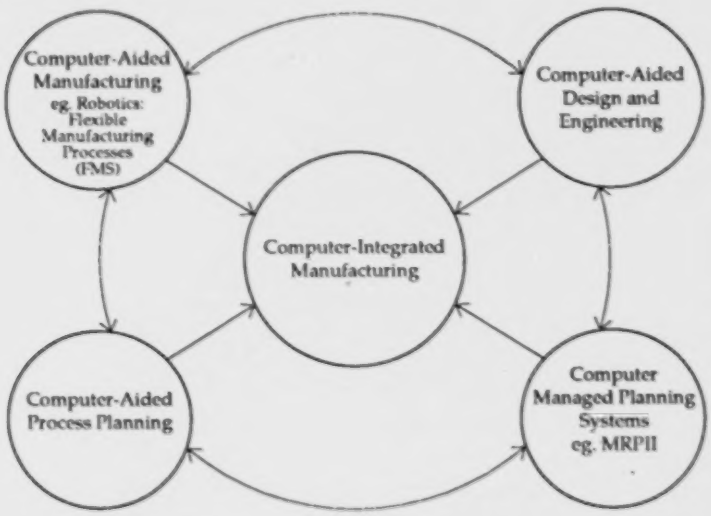
The elements of advanced manufacturing technology (AMT) can be seen from Figure 11. The US Committee on the Effective Implementation of Advanced Manufacturing Technology also attempted to spell out the elements of AMT. It is argued that AMT involves several types of technology which were:

> computer-aided manufacturing (CAM) [which] encompasses flexible manufacturing systems (FMS), robots, material handling devices, and numerically controlled (NC) machines, including computer numerical control (CNC) and direct numerical control (DNC). CAM also can include computer-aided testing. Computer-aided design (CAD) and engineering (CAE) can vary in sophistication from computers that serve as electronic drafting boards to those that test alternative designs on the screen for stress, function, and other characteristics, and then translate the design into a program to produce the product. Manufacturing resource planning (MRP II) is software that translates demand for products into parts needed to produce them and orders the parts from inventory or from suppliers so that they will be available when

needed. Computer-aided process planning (CAPP) is software that routes parts through the factory to maximize operating time and eliminate bottlenecks. (Committee on the Effective Implementation of Advanced Manufacturing Technology 1986, pp. 7, 9)

The four elements of AMT can be integrated, as Mitchell suggested, via local area networks leading to computer-integrated manufacturing (CIM) (see Figure 12).

Figure 12 Scheme for the integration of four types of advanced manufacturing technology


Computer-Aided Manufacturing eg. Robotics: Flexible Manufacturing Processes (FMS)
Computer-Aided Design and Engineering
Computer-Integrated Manufacturing
Computer-Aided Process Planning
Computer Managed Planning Systems eg. MRPII

These ideas of advanced manufacturing technology or computer-integrated manufacturing have been central to US thinking on the development of post-1970s forms of work organisation. Between 1981 and 1986, US corporations spent an estimated $50 billion on the technology of computer-integrated manufacturing. Some of the biggest spenders were General Motors ($500 million on its new Hamtramck plant) and General Electric ($600 million in order to establish a pioneering CIM plant at St Louis to make dishwashers). Many of these high technology manufacturing experiments have run into problems in the latter part of the 1980s, leading to less emphasis on the high technology fix and more on the techniques and philosophy concerning flexible manufacturing. These ideas and their implications are discussed in Section 3.

What we have done in this section is to try to understand the sources of technology and the nature of its causal influence on work organisation,

management and skills. First, it has been argued that technology, as a set of variables, cannot be reduced to something else, whether market forces or societal power relations: it has an independent causal impact arising from the embedding of technology and innovative processes in institutions which are linked with military institutions and are not motivated by making a profit. Second, it was suggested that the ideas of Bell (1972) and Blackburn et al. (1985) were most fruitful in conceptualising the concrete processes of technological change. These ideas of phases of technological change have provided an essential context for considering new technology. One way of looking at the present state of affairs is provided by the US work on AMT and computer-integrated manufacturing; another way has been provided by the work on flexible specialisation.

SECTION 3

THE FLEXIBLE SPECIALISATION THESIS

One of the dimensions of the machine–product relation is the level of dedication or flexibility. This dimension has assumed critical importance during the past fifteen years because of its association with changing product markets; for many analysts this has become the 'era of flexibility' (see Adler 1985, p. 7). Even for critics of the flexible specialisation thesis, like Iain Campbell (1990), there is an acceptance that significant changes in workplace relations and work organisation have occurred during the past fifteen years. However, because the term has been applied to both the labour and nonlabour aspects of work organisation, the meanings attached to 'flexibility' have become diffuse: the term has been stretched beyond usefulness. In general, it is best to focus on a basic notion of flexibility that is defined as:

> Process flexibility—the ability of the production system to process a wide variety of parts and assemblies without extensive intervention from outside to reorganise the system. In terms of parameters this can be expressed as the amount of time needed for system transformation in order to produce a new family of products.

From this key notion of process flexibility flows the ideas of labour flexibility (flexibility of labour inputs and functional flexibility) and machine flexibility. These are all (potential) aspects of process flexibility.

Many analysts (e.g. Jaikumar 1986) also refer to 'product flexibility'—that is, the dimension of standardisation–customisation. Most of the types of flexibility are simply aspects of process flexibility with a specific emphasis (e.g. routing flexibility, machine flexibility, etc.). However, the research does serve to remind us that flexibility is a complex issue, such that it is always necessary to ask: Flexibility of what?

Much of the writing about technology considers 'flexible automation' to be the core concept. However, Piore and Sabel (1984) have changed the name of the game by suggesting that the era of flexibility, or 'flexible specialisation', represents a new configuration of demand and supply that

is qualitatively different from Fordism. What is the core of their argument?

First, they perceive industrial history in terms of two divides: the first industrial divide constituted the shift from craft production to Fordism (or mass production); the second industrial divide constituted the qualitative shift from Fordism to the new era of flexible specialisation. What is an 'industrial divide'? Essentially, it is defined as a technological design space on a macro scale. Piore and Sabel define it as 'the brief moments when the path of technological development itself is at issue' (Piore & Sabel 1984, p. 5). In other words, an industrial divide is a point in time when a society has an opportunity to choose between a future based on one technological paradigm as opposed to another. It is easiest to summarise these ideas in a table format in terms of key variables (see Table 3).

Table 3 Key features of Fordism and flexible specialisation

	Fordism	FS
	Independent variables	
Market conditions	Stable	Uncertain
Product variety	Standardised	Differentiated
	Defining features	
Production regime/ Technology	Mass production	Flexible production Dedicated mechanisation Use of robotics, and programmable technology. Based on permanent innovation
	Associated factors	
Enterprise Organisation	Large corporations Unitary organisations changing to multi-divisional organisations	Smaller firms Decentralisation
Skill trends	Fragmentation and specialisation	Upgrading Multivalent skills
Employee Relations	Confrontationist or worker alienation	Greater tendency to forms of participation and worker involvement

Source: Adapted from T. Bramble, 'The flexibility debate: Industrial relations and new management production practices', *Labour and Industry*, vol. 1, no. 2, 1988, p. 192.

Piore and Sabel's ideas assume long-term and extensive changes in markets and the creation of niche markets with differentiated products. The argument is that there is a particular production regime arising from the changing product markets and task structures. Fordism implies mass

production and dedicated mechanisation whilst flexible specialisation involves computer-aided manufacturing, robotics and programmable technology. Fordism is predicated on large organisations; flexible specialisation is associated with smaller firms. In addition, Fordism involves a particular set of industrial relations which are confrontational at a collective level, or if collective organisation is absent then it is assumed there is widespread worker alienation at an individual level (see Mathews 1989). Flexible specialisation involves increased participation. Why is this? The nature of the technology is such that it is more costly to have worker alienation and sporadic disputes. This hypothesised tendency toward increased consultation and participation does not derive from employer paternalism but arises out of the nature of the production regime.

It can be seen from Table 3 that flexible specialisation is virtually the flip side of Fordism: large corporations are replaced by decentralised production and increasing numbers of small firms. Markets become fragmented with extensive 'niche' production. In terms of skill trends, a phase of deskilling is replaced by one of upgrading and cooperative industrial relations. It is important to note that the flexible specialisation thesis incorporates a view of long-term skill trends. We will examine the realities of this vision later, but what are the prime movers of this industrial 'flip over': What are the basic dynamics?

The nature of the causal links in the flexible specialisation thesis are left ambiguous in Piore and Sabel's work. Bramble (1988) attempts to mark out the basic linkages in connection with the 'first' and 'second' industrial divides (see Figure 13). The primary variables are the nature of the market interacting with the pattern of competition (large firm versus small firm) and available technology. Piore and Sabel deny that they are technological determinists (pp. 261-2). For instance, in relation to the second industrial divide, they argue that:

> If the computer appears to be the cause of industrial flexibility, this is probably less because of its applications than because, malleable as it is, it has helped crystallize the vision of a flexible economy just as the costs of rigidity were becoming obvious. (Piore & Sabel 1984, p. 262)

Nevertheless, they accept that there is an independent dynamic of technology and they use the notion of 'technological paradigm' throughout their book.

These configurations of market and technology shape the production regime which influences skill trends and employee relations. Whether extensive skill upgrading and managerial high-trust strategies are essential to successful competition under the new market conditions is not totally clear. This issue is raised by Bramble in a reinterpretation of the flexible specialisation thesis. This argument is considered in the next subsection in

the context of a critique of the overall flexible specialisation thesis. A number of trenchant criticisms of Piore and Sabel have been raised (e.g. see Reading 5).

Assessment of the flexible specialisation thesis

Bramble (1988) provides a neo-Fordist critique of Piore and Sabel's argument by reinterpreting the chain of events. First, it is argued that there has been no qualitative change of economy or industry that would justify the label 'second industrial divide'. There has been no development of a skill or craft utopia, instead there has been widespread continuation or modification of old practices. This view of continuity versus radical change is the axis which divides so-called 'neo-Fordist' writers from the 'post-Fordist' writers.

Bramble starts with the economic recession which occurred in many OECD countries at the beginning of the 1970s and led to a concentration and centralisation of capital rather than the development of small firm capitalism suggested by Piore and Sabel. This leads to a thrust toward cost cutting. Employers are faced with increasing pressure on costs which then leads to three alternative production strategies, not simply to a second industrial divide. In many firms it leads to an intensification of mass production and Fordist methods (e.g. in the clothing industry and mass production food industry). Alternatively, there is a switch to smaller batch production which splits into two routes, one of which is product simplification and automation, leading to work routinisation. This set of strategic choices does not fit with Piore and Sabel's argument. The second route is a switch to product variety and programmable production which results in an increase in the potential strategic power of workers because of the pervasiveness of the impact of stoppages, down time, etc. It is a bit like everybody being in the position of an air traffic controller. This leads to cooption in order to minimise the impact of worker action.

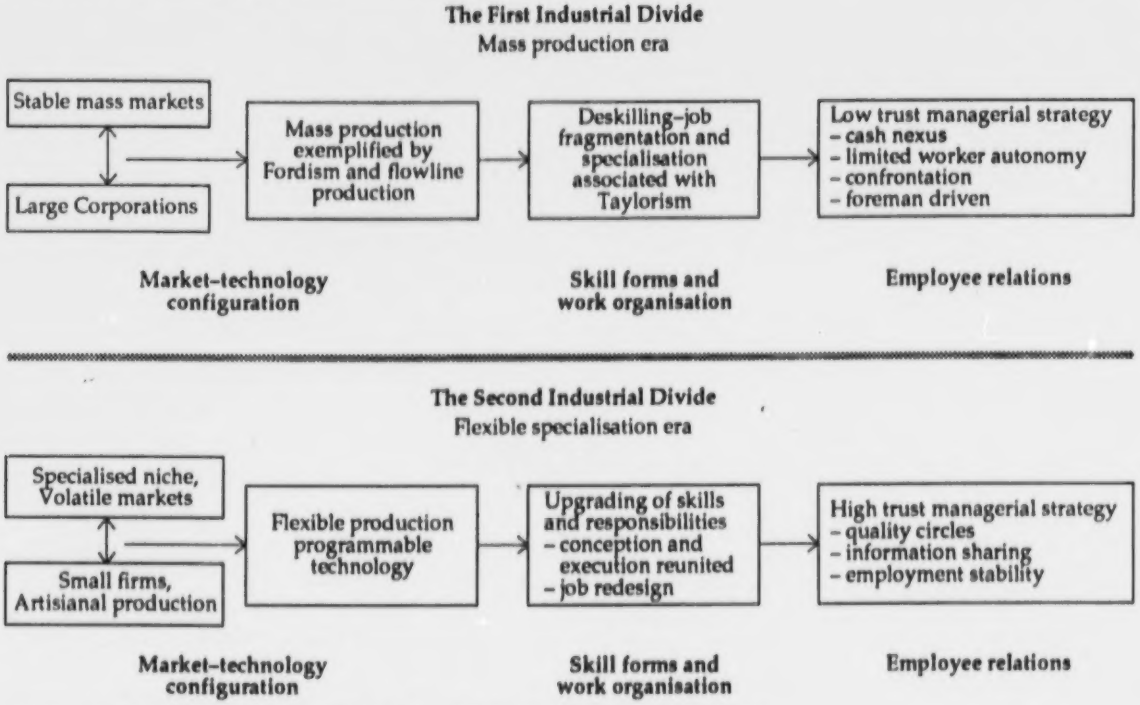
Bramble agrees that there is some empirical evidence for what Piore and Sabel are saying—but it is nothing like a comprehensive picture. Even if one starts with similar premises to Piore and Sabel (i.e. the economic crises of the 1970s and 1980s in many OECD countries), the subsequent implications are radically different. It is the cost-cutting impact arising from restructuring that is critical.

Williams et al. (1987) provide a much more trenchant view of the flexible specialisation thesis. Essentially, their argument is that the second industrial divide works at three levels:

1 it provides a theory of types of economy;

2 it presents a metahistory of the development of technology and

Figure 13 The flexible specialisation thesis



Source: Adapted from T. Bramble, 'The flexibility debate: Industrial relations and new management production practices', *Labour and Industry*, vol. 1, no. 2, 1988, p. 195.

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modern manufacturing; and

3 it presents an analysis of the 1980s economic and industrial crises.

Williams et al. reject Piore and Sabel's arguments in all three areas. They argue that the notion of flexible specialisation is not well defined and flexible specialisation or mass production cannot be identified in any particular instance at an industry or an enterprise level (see Williams et al. 1987, p. 417). The basic distinction (mass production versus flexible specialisation) involves at least three dimensions:

1 dedication–flexibility of process technology;
2 standardisation–customisation of products; and
3 the length of the production run.

It is suggested that these dimensions do not necessarily align.

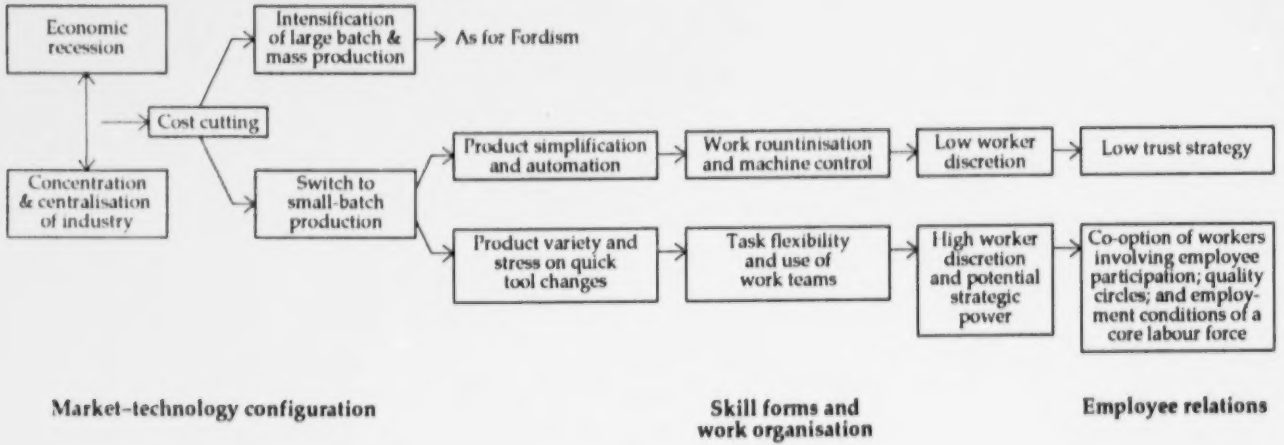
What is the evidence for the break-up of mass markets? Smith (1989) interrogates this in relation to the mass production food industry and concludes that there is no evidence from case study or survey data of the disintegration of mass markets or mass production modes. Smith's own research, based on the firm of Cadburys, led him to conclude that:

> A strategy of product and company globalisation, not fragmentation and decentralisation of products [was in evidence] ... Cadburys has been warmly embracing Fordism, reducing the number of products by over half in the last ten years and simultaneously internationalising their market. (Smith 1989, pp. 213–14)

In relation to the metahistory of technology, it is argued that a classification of industries is required and that Piore and Sabel attempt to 'stuff too much into the same bag' (Williams et al. 1987, p. 417). Industries need to be classified into complex consumer goods (typical assembly line industries), simple consumer goods (clothing, furniture, etc.) and capital intensive processes. The notion of Fordism, central to Piore and Sabel's argument, is seriously misleading as a model because it ignores the broad range of industries that are not based on complex consumer goods. Moreover, even in relation to assembly line industries, Fordism did not provide a strategic model. Most of Ford's imitators and successors did not follow his business strategy of relying on one long-lived model, but produced a family of interrelated models. Indeed, Tolliday and Zeitlin (1986) recognise this trend and link it with General Motors and Alfred P. Sloan (the Chairman of General Motors in the 1930s). 'Sloanism', as they call it, involved:

1 product differentiation—a car for every purse and purpose—associated with autonomous product divisions;
2 semispecialised manufacturing tools at the level of process technology rather than dedicated equipment;
3 an increased percentage of skilled workers compared to Fordist-type

Figure 14 Reinterpreting the flexible specialisation thesis


Economic recession
Concentration & centralisation of industry
Cost cutting
Intensification of large batch & mass production
As for Fordism
Switch to small-batch production
Product simplification and automation
Work rountinisation and machine control
Low worker discretion
Low trust strategy
Product variety and stress on quick tool changes
Task flexibility and use of work teams
High worker discretion and potential strategic power
Co-option of workers involving employee participation; quality circles; and employment conditions of a core labour force
Market–technology configuration
Skill forms and work organisation
Employee relations

Source: Adapted from T. Bramble, 'The flexibility debate: industrial relations and new management production practices', *Labour and Industry*, vol. 1, no. 2, 1988, p. 195.

methods; and

4 numerical flexibility of labour achieved through seasonal lay-offs. (Based on Tolliday & Zeitlin 1986, pp. 4–5)

Sloanism was a rather different model of mass production to Fordism and indicates the complexities of the development of the assembly line industries—complexities that are glossed over by Piore and Sabel.

In relation to the analysis of the present situation and trends, Williams et al. and some other authors argue that the evidence for the effects of new technology on flexibility and skill upgrading is incorrect. New technologies (e.g. robotics and flexible manufacturing systems (FMS)) are not that flexible. 'Robots cannot be re-programmed for new models by pressing a few buttons. That is a myth' (Williams et al. 1987, p. 430).Similarly, Adler points out that 'an assembly line ... that can costlessly switch between large and small cars is still in the domain of engineering fiction' (Adler 1985, p. 8). It is argued that the fundamental economies of scale have not changed. Overall, the effects of new technologies are mixed, but they do not herald a new flexible specialisation that is based on craft methods and low, fixed costs.

Nevertheless, if post-Fordism theses are wrong because the benchmark of Fordism is an extravagant characterisation of a complex era, then how can we further discussion of the present period? There are three basic views:

1 The level of continuity is sufficient across a range of industries such that no special analysis is justified. Technological and organisational changes may be occurring, but they are not qualitatively different. This is the neo-Fordist argument.

2 Extensive changes are occurring at an ideological level (the need for worker commitment, human resource management, etc.), but not at a material level. This thesis is a modification of the neo-Fordist argument.

3 There are qualitative changes (something novel is occurring in the present processes of restructuring) but concepts other than post-Fordism are needed.

My own view is a combination of points (2) and (3). If this is the case, then what concepts are on offer? If not Fordism, then what should be the benchmark? Apart from post-Fordism, three general ideas are on offer:

1 Increasing internationalisation plus mobility of capital

Capital mobility accelerates the pace at which technology engulfs entire industries and spreads across national boundaries. The Pacific Ocean no longer insulates an economy.

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2 The concept of 'Japanisation'

This concept assumes the cultural diffusion of a Japanese model of production, either on the basis of economic dominance and the spread of Japanese multinationals or because the Japanese got there first. In other words, Japanese managers responded more quickly than managers in other industrial economies to the new configuration of product markets, labour market factors and technology. Over time, faced with the same problems, Western managers have been influenced by the Japanese solutions.

3 The concepts figuring in the idea of 'Advanced Manufacturing Technology' (AMT)

AMT is a US-derived concept that is technology centred. AMT, it is argued, involves several types of technology leading to computer-integrated manufacturing (CIM). However, it is assumed that the CIM technology has human resource management implications, such that the possibility of costly production errors requires a highly skilled, flexible and committed work force (see Committee on the Effective Implementation of Advanced Manufacturing Technology 1986).

The ideas around AMT carry less intellectual baggage than the flexible specialisation thesis. There is no inbuilt model of industrial history, which is a major advantage. The ideas around Japanisation carry the intellectual baggage of Japanese culturalism, which has provoked a fierce debate. I will not attempt to deal with the extensive literature on Japanisation here (see Schonberger 1982; Watkins 1991).

The flexible specialisation thesis and skills

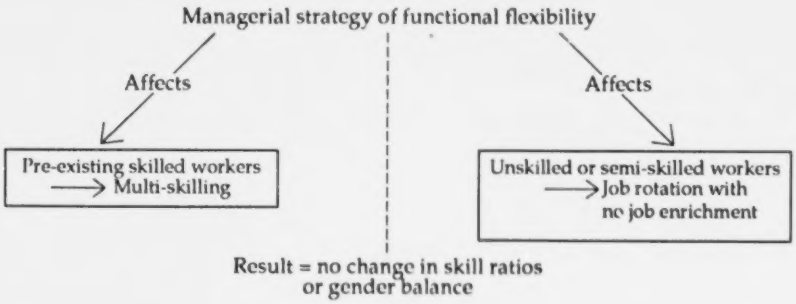
The flexible specialisation thesis implies that as firms and industries take up flexible automation the nature of skills will change. In general, flexible technology is seen to need the flexible worker, who is assumed to be a type of multiskilled craftsman (note the gender blindness here). The overall trend will, then, be one of upgrading. Piore and Sabel offer three reasons why the skill trend will take this direction. First, it is suggested that companies cannot afford repeated trials to perfect each set-up in small-batch production. Consequently, workers' skills are crucial for debugging programs or intervening when production falters. Second, skilled-worker knowledge is essential in a context of permanent innovation. Third, workers require broader skills in order to master new responsibilities when firms repeatedly change product lines. (Piore & Sabel's arguments are summarised in Shaiken et al. 1986, p. 167.)

This set of linkages begs many questions. First, it is a mistake to assume that all new technology is flexible technology or that the flexible

potential is being fully utilised. The evidence, so far, is that flexible automation is not being used to the extent that the flexible specialisation theorists imply (Wood 1989, p. 16; see also Jaikumar 1986—the US flexible manufacturing systems studied by Jaikumar produced only ten parts per system).

Second, even if flexible automation is being installed and is being used, what are the effects on jobs? Is there a match, or a trade-off, between hardware flexibility and labour flexibility? To what extent does increased flexibility of process equipment increase or decrease the demand for labour flexibility? The high cost of capital equipment (and FMS systems are expensive) imposes a need for intensive utilisation and may increase the need for numerical labour flexibility, but not necessarily functional flexibility. In addition, the adjusted potential of the capital equipment may reduce the need for workers' skills and flexibility. It is certainly the case that not all jobs will be affected equally. Indeed, the calls for 'labour flexibility' may simply intensify the existing divisions of labour (see Figure 15).

Figure 15 Managerial strategy of functional flexibility



If these existing divisions are reinforced, then the outcome may be unemployment and skill polarisation. This is an issue that Piore and Sabel (despite their previous writing) tend to ignore. Wood underlines the point. He states:

> Piore and Sabel nevertheless are extreme, so their over-concentration on the potentialities of new technology in the 1980s means that there is a neglect of the job losses, unemployment, tightening of performance standards, labour intensification, changing employment contracts and reduction of the power of trade unions and workers' representatives which have characterized the decade—except in so far as their advocacy of flexible specialization is offering solutions to such problems. (Wood 1989, p. 19)

What data do we have on the link between flexible specialisation and skills? One useful empirical study is that by Shaiken et al. (1986). They

consider the link between the two on the basis of case studies conducted in the US manufacturing industry, studying mainly metalworking firms. The firms were chosen as advanced users of programmable technology in batch production. They concluded that:

1 There was little sign of the emergence of the new craft worker described by Piore and Sabel. On the contrary, there was a tendency toward a reduction in the substantive complexity of machinists' jobs (see Shaiken et al. 1986, pp. 169, 172–3 & 181).

2 There tended to be a centralisation of work-planning procedures—a process welcomed by management (see Shaiken et al. 1986, pp. 173–4).

3 The introduction of broad job classifications, which was certainly happening in the plants studied, was associated with increased work intensification and stress for operators, supervisors and maintenance workers (see Shaiken et al. 1986, pp. 178–9 & 181).

In general, Shaiken et al. concluded that work restructuring was not associated with a multiskilled work force and that in the plants they studied. 'Managers ... introduced new technology guided by a vision of the automatic factory, or continuous process plant, not nineteenth century craft production' (Shaiken et al. 1986, p. 181). Shaiken et al.'s research offers no support for the flexible specialisation thesis in terms of the flexible specialisation/upgrading link.

The limits of flexibility

I have pointed out elsewhere that there are limits to mass production and its dedicated production methods—economic, technical and organisational limits. Such systems depend on the level and composition of demand plus the available technology. In addition, Fordism involves coordination and control costs (see Littler 1985, pp. 18–19). However, if we move to the other end of the dedication–flexibility spectrum: Are there limits to flexibility? Is it the case that 'the more flexibility the better'? If not, what sets the limits to flexibility?

Let us consider the enterprise as an economic entity. As I have pointed out, within production systems the economics are such that there is a continual tension and trade-off between static efficiency (i.e. cost minimisation) and flexibility (i.e. adaptability to changing markets). The high costs of automated flexibility have been the major barrier to the development of flexible automation. Adaptability to markets has been achieved by small-scale production, workers with a broader task range, rapid rates of organisational creation and dispersion based on social and economic networks (see Stinchcombe 1968, pp. 258–62). This dynamic efficiency has been

bought at a cost—a cost structure which looks more foreboding if flexible automation is involved. The possibility of unanticipated changes in the economic environment—changes in product markets, changes in relative factor prices (i.e. costs of inputs) and changes in production technology—gives rise to uncertainty, which may be met by a reduction in fixed costs. Flexibility in the production process, including labour flexibility, provides a large increase of adjustment potential in the face of uncertainties, but at a cost. Let us focus on labour flexibility.

According to Hill and Blyton:

> The essence of manpower flexibility is the pliability of working arrangements, or the ability of management to adjust the quantity, composition, function and intensity of labour inputs to the changing demands and requirements of the organisation. (Hill & Blyton 1986, p. 2)

Increasing flexibility may increase training costs, coordination costs and management costs. In addition, worker commitment may decline, leading to reduced levels of cooperative effort. Flexibility depends on slack labour markets. There is little evidence, so far, that flexible firms have been successful in achieving lower labour costs. It should be noted that Japanese firms have emphasised increased flexibility of capital associated with flexibility of labour use (multiskilling and job rotation) but with limits to the numerical flexibility of labour. Western and Australian firms have, in many instances, reduced or plateaued capital spending and pushed the adjustment costs onto labour by numerical flexibility alone—this represents a static response to adverse market conditions (see Atkinson 1987).

Above all, flexible automation depends on viewing unstable and unpredictable market conditions as likely to continue for a long time. If the 1990s witness the emergence of more stable configurations of demand and supply, some attempts to build flexibility may prove to be costly and myopic reactions (see Adler 1985, p. 8).

If the flexible specialisation thesis is confused then what sense can we make from the various threads of the debate? First, it is clear that endless extrapolation from limited case studies does not make much sense. To hypothesise the overall impact of new technologies would require a consideration of the interaction of supply and demand and the factors determining the rate of diffusion of new technologies (e.g. the costs of capital). Nevertheless, we can agree with various writers, such as Campbell (1990), that the technological change associated with microelectronics has a distinct character. The following propositions (partly based on the work of Jubb & Markowski 1988) seem to be the sensible points that can be drained out of the flexible specialisation and flexibility debates.

Proposition 1
The diffusion of microelectronics in process technologies will have an overall labour-saving effect—that is, a given output capability can be achieved with less labour. These effects are likely to be uneven from one industry or sector to another. In addition, the effects will be swamped in the short to medium term by the fact that the industries marked by the fastest rate of technological innovation are the fastest growing industries. There is no general rule as to how fast job elimination progresses relative to job creation within an industry or across sectors (see Adler 1985, p. 7).

Proposition 2
The diffusion of new technologies during the 1980s and 1990s is not associated with determinate skill trends. There may be a slight overall upgrading effect but this is combined with areas of significant deskilling.

Proposition 3
Economies of scale will decrease in importance because, other things being equal, the cost penalties associated with smaller scale operations will be lower. However, this effect is likely to be weak. Dedicated automation will continue to be most efficient in relation to the production of homogeneous outputs. In particular, process industries (e.g. chemicals) will continue to be scale oriented. The costs of system changeover are extensive in process industries, in part because the levels of 'output jointness' are low—that is, there is rarely a broad range of products that can be tapped into (oil refineries cannot readily produce beer).

Proposition 4
Economies of scope will become more important and the scope of automated production systems will increase with the diffusion of flexible manufacturing systems and computer-integrated manufacturing systems.

Proposition 5
The response flexibility of production systems will increase in association with increased scheduling flexibility. The problems of the 'variable disjuncture of information' (i.e. incomplete and scattered knowledge of the production system) are solved by new process control technologies (e.g. MPP II) or by the work-team links ('customer-supplier relations') associated with just-in-time systems.

Proposition 6
The overall effects of technological change will depend on the interactions among scale, scope and response flexibility. There will not be a one-way effect (contra unilinear theories). In the case of batch-production situations, where the existing production systems are relatively flexible, the diffusion

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of new technologies is likely to produce increased centralisation of production (this contradicts Piore & Sabel). Smaller producers may have to become larger, increase their level of automation and narrow their scope of production. In the case of mass-production contexts, the new technology will lead to greater diversification of production in response to changing market demands, but the effects could be relatively limited.

Proposition 7
There will continue to be an ideology of progress (e.g. flexible specialisation, the 'flexible firm', upgrading, multiskilling, etc.) in order to achieve an acceptance of change and the need for change. This ideology will be the language of the purpose of the employers.

The 'Conclusion' attempts to draw the argument together and contrasts the deskilling paradigm with the flexible specialisation paradigm.

Conclusions

The debates concerning technology have proceeded in terms of two paradigms: deskilling and flexible specialisation, linked respectively to the names of Braverman and Piore and Sabel. These two paradigms have had very different implications in relation to skill trends. The skill formation implications of the two paradigms are summarised in tabular form (see Table 4).

Table 4

	Deskilling Paradigm	Flexible Specialization Paradigm
Long-term skill trends	Dynamic of deskilling	Dynamic of upgrading and multi-skilling
Structure of control	Based on Taylorist ideas and techniques	Career structures and internal labour markets for core workers
Employment relations	Minimum interaction model of least commitment	Worker commitment plus core/ periphery labour market structure

It can be seen that the skill and training implications of these two paradigms are directly contradictory. Whilst we can contrast these two paradigms, it is not easy to make final judgments, particularly in the absence of well-defined concepts and extensive data sets. Both paradigms are over-simplistic and attempt to achieve a level of universal descriptive and narrative structure that is conceptually misleading. It is not helpful to

theory-building to proceed in terms of endless extrapolation and universalisation. Such a process precludes the systematic development of theory. Moreover, a switch to 'flexibility' narrows the focus and the problematic. In general, the crucial criterion of theoretical development is in terms of narrowing or broadening the problematic: according to this Lakatos test, the recasting of problems in terms of 'flexibility' reduces the number of issues that can be addressed. Why? Because flexibility is a managerialist concept stemming from specific concerns and objectives.

Flexibility as a focus points to no specific set of socioeconomic relations. Indeed, it buries them. So the shift in focus has two effects:

1 it moves the emphasis away from fundamental socioeconomic relations; and

2 it refocuses on specific managerial objectives based on the problems of the 1980s.

Consequently, the so-called flexibility debate reduces and narrows the terrain of analysis.

The preceding point is not so true of flexible specialisation and post-Fordist literature more generally. Indeed, Campbell (1990) spells out some of the positive aspects of the post-Fordist literature. First, it assumes the importance of work and production relations in the life of a society, unlike some earlier theories (e.g. those of post-industrialism). At the same time, these writings, like those of the labour process debate, attempt to link the development of labour processes with those of broader structural change, including the linkages between production and consumption patterns and the processes of capital accumulation. Finally, the post-Fordist analysts:

> quite rightly argue that there is something novel in the nature of the current period and in the changes at the workplace as a result of restructuring. They quite pertinently imply that the assessment of these changes is an urgent task for labour-oriented research. (Campbell 1990, p. 13)

Nevertheless, whilst we can recognise strengths and positive elements in the post-Fordist literature to date, it does not imply that a successful theoretical structure has been built up which enables us to link changes in technology with long-term skill changes. This is a central issue that has not been solved.

In many ways, the weaknesses of Braverman's work in the mid-1970s are repeated in Piore and Sabel's work in the mid-1980s. Both seize on limited arguments and limited cases in order to build an over-generalised grand structure. This argument is elaborated in Table 5, where the respective conceptual problems are outlined.

However, spelling out conceptual simplicities will not change the ever-present tendency to generate them. The formation of ideas is a struc-

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tural process: it can be argued that the language of flexible specialisation exists because of ideological imperatives. Some time ago, before the publication of Piore and Sabel's work, I wrote the following:

> At present we may be witnessing the emergence of a new cluster of ideas, a new ideology which marks out the parameters of future technological choices. The elements of that ideology—'Information Technologyism'—are not yet in place and there is no standard-bearer. Probably the ideology will be built around the concept of a system and, unlike most previous managerial ideologies, it will be seen as universally applicable across all sectors, not only manufacturing but also in services. (Littler 1983, p. 144)

Table 5 A comparison of the conceptual problems of Braverman and Piore and Sabel

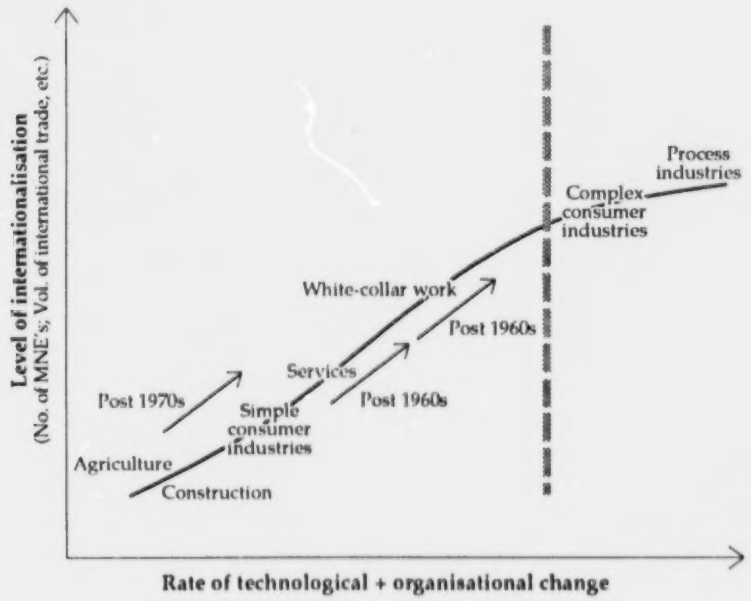
Braverman	Piore and Sabel
1 Attempt to achieve a simple narrative structure of industrial change, based on a dichotomy between craft production and Taylorism/mass production	1 Attempt to achieve a simple narrative structure of industrial change, based on a dichotomy between craft production and mass production
2 Unilinear trajectory involving deskilling and increased managerial control	2 Implied unilinear trajectory involving upgrading and increased collaboration between workers and management
3 Lack of analysis of different sectors, industries and countries	3 Lack of consistent analysis of different sectors and industries. Some analysis of different countries, but disparate cases (e.g. UK) ignored
4 Failure to clearly conceptualise key ideas such as skill and technology	4 Failure to clearly conceptualise key ideas such as 'flexible specialisation' and technology.
5 Vagueness about dates and periodisation	5 Vagueness about dates and periodisation
6 Romanticism of the past	6 Romanticism concerning the future
7 Confusion over levels of analysis. Ideology and practice confused	7 Confusion over levels of analysis. Sector-specific and firm-specific changes converted into a metahistory

In many ways the flexible specialisation thesis is fulfilling precisely this ideological set of functions. This, combined with the appeal of simple phase theories of development, will make it difficult to shift from the intellectual horizon.

It is clear, therefore, that neither the deskilling paradigm nor the flexible specialisation thesis have provided an adequate metahistory of

industrial development: nor can they. In any modern economy there is a diversity of production forms; industrial and capitalist variety is normal. Moreover, I pointed out in the 'Introduction' that there are, and have been, significant variations among sectors. Because of this pattern of uneven development, it is useful to make sense of some of the recent arguments by breaking down the level of generality (see Figure 16). Following on from Williams et al. (1987), manufacturing industry is separated into process industries, complex consumer industries and simple consumer industries.

Figure 16



In addition, reference is made to white-collar work, services and so on. The illustrations are not comprehensive: for example, nothing is said about the producer industries (e.g. machine tools). The argument needs to be rounded out by considering the entire range of industries. Nevertheless, a basic argument can be made which is as follows.

First, the rate of technological and organisational change has varied markedly between industries over this century. At one end is agriculture with a very limited set of changes (until recently) and with many localised markets. At the other end are the process industries (chemicals, oil, etc.) which have been at the forefront of technological development, plus the complex consumer industries (cars, electronics, etc.) characterised by mass production and Fordism. It is also the case that these two sectors have been

the most internationalised, marked by dominant numbers of multinational corporations and by a high volume of international trade. There is a distinct gap between these two sectors and the rest of industry, such that these sectors have been seen as the 'leaders', providing the managerial paradigms of the twentieth century (Fordism, automation, etc.). The simple consumer industries (clothing, furniture, toys, food processing, etc.) plus services and white-collar work have, until recently, been marked by much lower rates of technological change and by smaller firms selling into more localised markets.

Second, several sectors (e.g. simple consumer industries, services, white-collar work) have been changing dramatically in the post-1960s, or post-1970s, period depending on the sector. The direction of change has been to move up the graph diagonally toward increased globalisation and technological change (e.g. the development of the fast food industry in the service sector, etc.). These changes have frequently been along the lines of increasing the application of Taylorite and Fordist techniques, as Smith makes clear in connection with the food processing industry (1989, pp. 213–14; see also Reeders 1988). Consequently, Piore and Sabel confuse at least two radically differing processes of development:

1 restructuring in the complex consumer industries, and the process industries to a lesser degree; and
2 the catch-up process of other industrial sectors (e.g. services) along Fordist (not post-Fordist) lines.

This conflates two very different sets of processes. Indeed, Smith argues that the flexible specialisation concept is constructed in this confusing 'catch-all' manner:

> the term 'flexible specialisation' is constructed to embrace both handicraft production supported by local states and mass production sectors undergoing restructuring, batch industries using new technologies, as well as the construction and fashion goods sectors. (Smith 1989, p. 204)

Third, the two basic dimensions of Figure 16 are linked—globalisation reinforces the rate of technological change. Clearly, globalisation reinforces mass production, but more than that, as we have seen, capital mobility across national boundaries accelerates the pace at which technology engulfs entire industries.

Overall, we can conclude that in order to make sense of the impact of technology and long-term skill trends, it is necessary to shift from a global level of analysis to a sectoral level of analysis. Only when we understand the dynamics of individual sectors can we properly assess the global assertions of a Braverman or a Piore.

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READINGS

1

NEW TECHNOLOGIES, NEW SKILLS

P. ADLER

P. Adler, 'New technologies, new skills', *California Management Review*, vol. 29, no. 1, 1986, pp. 9–28.

It is not an easy task for managers to ascertain the skill requirements of new technologies. But mistaken assessments can be costly. Reflect for a moment on the following three cases:

- *The numerically-controlled machine-tool case:*

  NC machine-tools were originally developed with the dual purpose of diminishing reliance on skilled machinists and augmenting technical capabilities. Early vendors' advertisements were very clear: with the new machines, after establishing the appropriate software to select and guide the cutting tools, "anyone can do the second piece."

  But in reality, in the three decades since the development of the NC machine-tool, its adoption has not led to any general trend to the elimination of the skilled machinist. Surveys show repeatedly that not only are most NC machines operated by skilled operators, but new training requirements and higher levels of responsibility are the general rule.

  Companies that took the vendors' suggestions literally, setting up their shops with expensive machines and inexpensive labor, found that the unscheduled downtime, the cost of errors, and the limited flexibility of this configuration severely limited the payoff to their investment.[1]

- *The Three Mile Island accident:*

  Decades of research into the control of nuclear facilities had produced a highly sophisticated system of monitors and fail-safe devices. The premise and the promise of this engineering work were that a better design will call for less, and less complex, human intervention. If the human element was the weakest link in the control chain, the least reliable component, it seemed logical to aim to "design the operator out of the control loop."

The Nuclear Regulatory Commission's investigation of the Three Mile Island near-catastrophe revealed, however, a crucial flaw in this reasoning. The dominant design philosophy has been blind to the link between more complex control mechanisms and more complex and unpredictable failure patterns. The control functions that are successfully automated are the simpler ones. The number of operators required can thus thereby be reduced, but the functions of the remaining personnel will be more, not less, demanding. Conclusion: there is a pressing need for significantly more sophisticated training than the industry or its regulators ever envisaged.[2]

- *Or consider the case of large banks as they move from overnight batch processing systems to fully on-line "one-terminal per teller/one data-entry per transaction" systems:*

In a case I have examined in some depth, that of a major French bank with over 30,000 employees and a world-class computer system, management hopes for the pay off to this major advance in their level of automation were clear. Low-level clerical jobs like the teller's should be "de-skilled": they would not need any knowledge of banking procedures, because the sequence of processing steps they had to follow would be indicated on the terminal screen.

Not quite halfway through a five-year switch-over program to the on-line system, the bank found itself confronted by two major revisions to its "de-skilling" scenario.

First, operations managment had become very concerned by the considerable fragility of a fully on-line system that integrated some 2,000 bank branches. The people at the extremities of this vast system would have to be absolutely reliable, since any data they entered, as long as it passed some simple tests for internal coherence, would be fed instantaneously into all the bank's accounts and the corresponding funds transferred instantaneously. This concern for data integrity was slowly filtering up to general management.

Second, having begun with the assumption that skill requirements would be significantly reduced by the latest phase of automation, management had only slowly come to recognize a pressing need for training of lower-level personnel, not only in basic computer literacy, but also in the nature of the overall computer processing system and even in the logic of the accounting procedure.

These two considerations were imposing themselves on the bank with some force. Without costly remedial actions and revisions to their automation plan, the bank risked grinding to a halt under the accumulated weight of polluted databases, erroneous transactions, and angry customers. For a company where all the clericals had been trained exclusively on the job by fellow clericals, the discovery was a shock.

The Myth of a De-Skilling Trend

These three examples are not isolated instances. Such costly discrepancies between expectations and realizations for technology's impact on skill requirements are only too common. This article suggests some ways for avoiding these unhappy surprises for management. But before discussing them, it is important to measure the obstacles faced by managers in making their judgements.

The assessment of a new technology's impact on skills is inherently difficult. Management's information base for the task is almost invariably insufficient. The vendor is an interested party when it comes to performance estimates and is rarely available for advice on implementation.

Managers are therefore often forced to rely on a guiding assumption. Sometimes this assumption turns out to have been too high: due to plant tradition or exaggerated fears of the difficulty of mastering the new equipment, some plants assign skilled craftsmen to the new jobs, only to find that after the debug period, a lower level of personnel is more appropriate. But more frequent, and often in the end more costly, is the inverse error — underestimating the skills required for effective operation of new systems. Managers are often attracted by what could be called the "myth of de-skilling": the idea that as a general rule new generations of equipment have permitted and will permit reductions in skill requirements. This myth is a major obstacle to effective planning for the implementation of new technologies.

The de-skilling view is not altogether implausible. There are certainly cases in which automation has led to a reduction in skill requirements. Take the example of the professional-level insurance claims analysts responsible for the more complex cases. Computerization in this case meant that all the complicated procedures and decision parameters that were their expertise are programmed into the system, so that most of these cases can now be processed by a lower-level clerical worker.

The de-skilling view is, of course, in competition with what we can call the "upgrading hypothesis." Take the lower-level insurance claims processing clerks. For these employees — far more numerous than the professional-level analysts — the computerization process has simultaneously facilitated and upgraded their work. Such routine jobs now call for at least a minimum level of computer-literacy and often encompass a broader span of tasks.

In the struggle between these two views for preeminence as management's guiding assumption of what to expect from automation in the general case, the de-skilling case has, however, considerable support. First, there is the weight of traditional engineering doctrines. Machine systems design progresses under the momentum of a philosophy which focuses on perfecting machine performance. The problems confronted in the messy world of real implementation are relegated to a residual status, especially the critical

problem of coping with errors and contingencies. "Idiot-proof" is still very often the engineer's implicit norm. This philosophy is reinforced by the traditional industrial engineering job-design doctrine which reflects the "Scientific Management" equation of efficiency with specialized simplicity.

NC machining is perhaps an excellent example. If everything were to work as perfectly as the textbooks indicated, a lower-level machinist might indeed suffice to monitor the machine-tool as it is taken through its steps by the NC tape. But surveys show an average of 45 errors in each hundred new NC programs.[3] The machinist's skills are critical to the accurate and timely identification of those errors. With engineers overly confident that programming could be perfected, it took until the recent development of "computer numerical control" for machine design to permit the machinist to correct programs at the machine. And the Methods and Personnel departments are still debating whether they want to encourage such a blurring of job definitions.

Engineering doctrines are frequently compounded by the "good news" syndrome in organizational dynamics. People tend to select the least troublesome alternative to transmit up the organizational hierarchy. Thus, if we trace discussions of operations problems as they progress from first-level management upward, the hypothesis of operator carelessness comes to appear progressively more plausible, while the alternative hypotheses of poor systems design and inadequate operator training are progressively less frequently mentioned.

Another common thread running through the three cases cited at the beginning of this article is wishful thinking. Given the real uncertainty surrounding a new technology's impact, it is easy for management to fall prey to the sirens' song: "Skilled labor is more expensive; perhaps with new equipment we can do without." It is easy to extrapolate from needing proportionately *less* labor to needing *less-skilled* labor.

Indeed, the dominant pattern of U.S. industrial relations promotes such wishful thinking, by encouraging a myopia of the zero-sum game kind: "If it's good for management, it can't be good for the workers — and vice versa."

Complementing these influences is the continued presence of a venerable tradition of social analysis dating back to Adam Smith. A considerable body of opinion supports the intuition that machines "embody" workers' skills. And if the machine "takes over" progressively greater proportions of the worker's task set, the remaining job must surely be de-skilled.

The fallacy here, however, is easy to identify: for every task transferred from worker to machine, there is a new task created — that of deploying the enhanced machine capabilities. We still need, therefore, a guiding assumption as to the net effect of these additions and subtractions to the worker's task set.

Major research efforts of recent decades have focused on automation's skill requirements, but have often left the requirements of the highest levels

of automation intriguingly indeterminate.[4] To some extent, this result is justified by the fact that there is indeed a broad range of skill configurations that can more or less effectively be associated with highly automated systems. The higher the level of automation, the greater the room for managerial discretion in work design. But for another part, this "indeterminate" diagnosis reflects a failure to adequately grasp the qualitative shift in *types* of training, responsibility, and so forth required at the higher levels.

It is all too easy to ignore, underestimate, or misinterpret the new tasks like system monitoring and control. That is why, in the hope of permitting a clearer assessment of automation's skill requirements, this article identifies three qualitative changes in types of skill that often accompany automation: new types of task responsibility, a new degree of abstractness of tasks, and new levels of task interdependence.

The more systematic surveys of automation's skill requirements (see Appendix 1) show that while the net effect of subtractions from, additions to, and qualitative mutations of, the worker's task set is most definitely not *always* positive, the *general* trend has been an upgrading, not a de-skilling. This is the most plausible interpretation of the data that shows both a secular shift in the occupational structure, which has given more weight to the more-skilled occupations, and an increase in the skill requirements for most individual jobs.

There are, of course, numerous examples of real de-skilling. In particular, when product and process technologies are very stable over time, there may be considerable gains to specializing jobs and thereby reducing average skill requirements. This explains why traditional design engineering's idiot-proofing approach is sometimes efficient and why management's de-skilling expectations are sometimes realized. The traditional auto assembly-line is perhaps the best example of how effective this approach can be.

But it is important that managers not extrapolate the assembly-line model into activities that do not fit the special conditions which, for a certain period at least, made that model effective. Very few activities — indeed fewer and fewer of them — exhibit the degree of stability that justifies the de-skilling model.[5] The notion that de-skilling is the most likely outcome of automation is therefore a myth. Indeed the de-skilling view is a myth that is dangerous to effective management and competitiveness, since operations design premised on a guiding assumption that is incorrect will be outperformed, and costly realignments of personnel profiles will be necessary.

The choice of staffing pattern for a given technology always depends, of course, on a variety of factors other than purely technical ones. In particular, the stability or flexibility of operations, the characteristics of the labor force, and the prevailing industrial relations all play a role. This article, however, addresses the generalizations that rise above those contingencies.[6]

An examination of the case of banking computerization can help us identify useful generalizations about the new types of skill that managers responsible

for effective automation need to plan for. Banking is not often the place that one looks for general lessons in these matters; its particularities are distinctive. But we will see that the emerging technological configurations of large, on-line computer systems in banking provide an example which dramatically highlights the problems faced by a broad spectrum of industries.

The Evolution of Banking

The basic organization of bank processing has evolved through four key stages.[7]

If we look at this evolution from the point of view of the most labor-consuming of banking operations—demand deposit accounting (DDA)—we can see what this aggregate development of bank automation means for employees responsible for particular tasks.[8]

I have used a presentation developed by James Bright, the "mechanization profile."[9] The sequence of steps in DDA runs down the left-hand side, and for each step the table indicates the technical level of the process: the lowest level is the manual system dominant until the 1930s; it is followed by mechanical accounting machines introduced in the period 1930–1950; then off-line computers that were introduced in the 1960s and 1970s; and finally the on-line computer systems that have become prevalent in the 1980s. (See Figure 1.)

Two facts stand out:

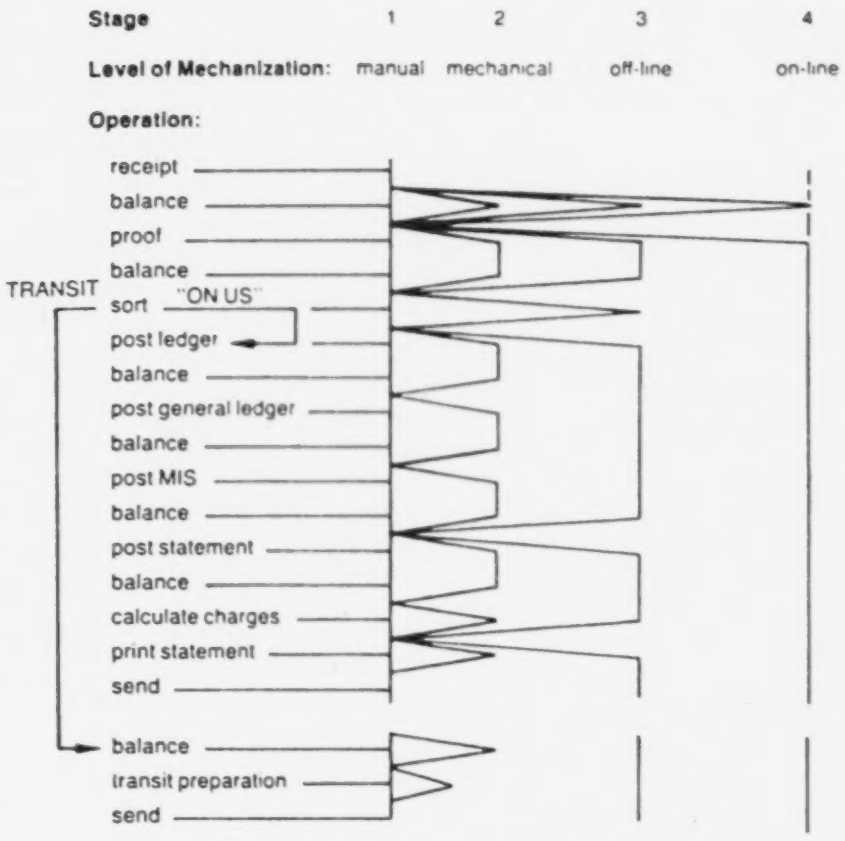
- At the second, mechanical level, we have much the same sequence of discrete operations as in the manual case, the only difference being the automation of account-balancing steps.
- But at the third level, and even more at the fourth, whole sequences of operations are programmed and are internal to the computer system. The number of times the check's key data are entered into the system is dramatically reduced.

How then should we characterize the effect of moving up the automation scale?

To say that labor has been "eliminated" is to say too much or too little. Too much because some employees are still needed to guide data-entry and to control for the system's correct functioning. Too little because, even leaving aside our curiosity for the new employees who are responsible for developing and maintaining the computer system, we want to know where employees have really been eliminated and above all we want to know what the remaining jobs look like.

A more precise term to characterize automation's impact might be *peripherization*: employees have been pushed from the center of the "account fabrication process" to the periphery of a powerful automatic system, into tasks of data-entry, system control, and system maintenance. Whereas previously some two-thirds of bank personnel were employed at fabrication

Figure 1. Stages of Demand Deposit Accounts Processing



tasks like bookkeeping, an increasing proportion is now in direct contact with the customer or working on higher-level professional-technical tasks. The parallel peripherization process in manufacturing automation is evident in the often dramatic reductions in "touch" labor.

What then are the skill requirements of such a system? If we imagine the organization of production in the bank as an old-fashioned pyramid, with a summit of managers, middle layers of professionals and supervisors, and a base of employees, large-scale computerization of the fabrication process seems above all to take a bite out of its base.

To the extent that such a simple image captures the process, it is easy to see why average skill levels tend to rise with automation. If, as is often the case, it is mainly (but of course, not exclusively) the lower-skilled layers of the pyramid whose tasks are automated, then the average level of the

remaining positions will be higher. Furthermore, some of the remaining jobs will be upgraded, and some new, higher-skilled jobs will usually be created. On the other hand, another subset of the remaining jobs may suffer de-skilling; but unless this de-skilling effect is of truly massive proportions, the total effect will be an upgrading.

Indeed, between 1969 and 1977, the period of most intense computerization, the proportion of lower-tier employees in major French banks fell from 58% to 45%, with the complementary gains spread across the professional/supervisory category (32% to 42%) and the management category (9% to 13%).

Management of these transformations calls for an awareness of the fact that the higher-level jobs may not go to current job-holders;[10] but it is of the utmost importance to have a correct sense of the aggregate trend, too. If the model derived from bank automation has any general applicability, this aggregate trend should be an upgrading one. The data on U.S. labor force trends cited in Appendix 1, weak as they are, do at least support our model.

Note, furthermore, that this image of automation generates a prediction totally at odds with the much-discussed "disappearing middle" thesis. If the computerized pyramid is redrawn to show the final shape of the new organization, we see a shift not towards an hour-glass but, on the contrary, towards something closer to a sphere.

But this is only the most rudimentary of characterizations of the skills required in the automated context. What, then, can be said of the quality of the remaining lower-level clerical jobs?

The new on-line computer configuration gives rise to some new features of work, or at least singularly reinforces certain existent features of the operating tasks. A closer examination will cast light on qualitative dimensions that need to be addressed in any serious skills assessment.

The New Features of Work

The features of work that have emerged as critical, as the bank moves into the highest levels of bank automation, cluster around *responsibility*, *abstractness*, and *interdependence*. The qualitative shifts in types of skill that have brought these three features to the fore are, I believe, central to the diagnosis of automation's skill requirements. An accurate sense of the changing requirements of banking clerical tasks in these three regards is essential to defining appropriate Human Resource Management and Operations policies. In this, the banking case may hold lessons for other industries.

Responsibility—The importance of employees' sense of responsibility at the higher levels of automation is hard to overstate. Quite independently of any humanistic job-enrichment values, it is advanced systems' vulnerability to errors that calls for a major shift in our thinking regarding responsibility requirements. The traditional importance of "responsibility for effort" is

displaced by a responsibility for results, for the integrity of the process.

Notice, first, that the bank is dealing with a level of automation that is in many ways qualitatively higher than even that of chemical refineries' "continuous flow" operations. In the bank, we have a veritable "instantaneous flow" system: once the data-entry is made, at the front desk or elsewhere on the system's periphery, the corresponding transaction is instantaneously effected, and, equally instantaneously, adjustments are made to all the relevant accounts.

Massive efforts are deployed to automatically check operators' authorization levels and data's internal coherence. And these efforts result in very ingenious cross-checking and personal identification code systems. In this way, the simpler errors are eliminated, and the *frequency* of errors is thereby reduced, as is indeed the *total cost* of errors. But the remaining errors are on average the more complex ones, and new sorts of errors are created that are often more difficult to trace. Computerization can thus reduce the total cost of errors even though the *unit cost* of the remaining errors — their potential impact, their discovery and rectification costs — may be augmented.

This generalization is supported by research in an altogether different environment, aircraft cockpits." Earl Wiener, in analyzing cockpit automation, offers an everyday example which captures this new automation-error model — the digital alarm clock: "Unlike the analog alarm clock, it can be set very precisely, but it operates on a 24-hour cycle; thus one can inadvertently (by default) set a wake-up time at P.M. instead of A.M. With the introduction of digital clocks a new blunder was born: the precise 12-hour error."

The prevalence of this new type of error gives the teller's job, like that of other lower-level clericals, a new and augmented importance, because in the new systems there is usually no one further down the processing chain to catch errors.

If errors are not picked up by the automatic filters, they can become nightmares. Putting databases on-line for both data entry and access, for example, means that whole sectors of the bank may find themselves using inaccurate data as the basis of subsequent operations or calculations. Another example is the local check processing operations that must stop entirely to resolve a discrepancy — and not just for half an hour; these problems can paralyze a whole unit for one or two days at a time. Why? Partly because the error detection system eliminates all but these, the most complex cases. But for another part, the sophistication of the system itself creates new problems. Audit trails, for example, may simply disappear.

These operators are now on the "front line" in the effective deployment of the system's much-enhanced capability. If the system goes down — which it does on average once a day, if only for a second — it is the tellers and operators who must assure themselves that the transaction they had half-completed will be effected without starting over, or alternatively, that the transaction can be restarted without inputting it twice.

The problem has its parallel in manufacturing. The active role of operators in avoiding accidents — whether it be "minor" accidents that can make or break a firm's quality reputation, or major ones like Three Mile Island — is an increasingly critical efficiency and competitive variable. This trend reflects not only new competitive conditions, but also an underlying technological tendency.

Effective analysis of the impact of computerization on work involves, therefore, an accurate assessment of the job's responsibility requirements. Workers have always had the responsibility of fulfilling their part of the "wage/effort bargain." But in banking, and perhaps in many other situations, these higher levels of automation call for a qualitatively different type of responsibility: responsibility for overall process results, not merely for the supply of a reasonable degree of effort. The responsibility-for-results solicited in the banks is not of a very high "level," but is so pervasive as to have become a critical competitive variable.

It is, of course, hardly new that managers want motivated, responsible workers. What seems to be profoundly new is the fact that this is no longer a wish but an operational imperative imposed on management by the nature of the automatic system.

Abstractness — As automation pushes workers out of fabrication and into peripheral, interface functions, there is a certain abstraction of tasks and of goals. Intellectual mastery therefore becomes a key performance factor.

Manual tasks become mental. Being computer-mediated, their mastery entails an extensive familiarity not just with a handful of codes, but with a whole new, more or less artificial, language. Operations tend to assume the algorithmic form of sequential decision trees. Handling a cash withdrawal at a front desk on-line terminal, for example, involves a minimum of nineteen distinct steps, where each step may lead off into supplementary steps of data-checking or file-updating. Thinking becomes "procedural": the key task of the employee is to size up the situation so as to select the right one from a set of procedures and to then follow that procedure through and be able to reconcile the procedure with any anomalies the situation might present. Learning to deal with anomalies and contingencies involves higher-order conceptual processes, such as when the document lacks some data, when the system signals some irregularity, or when the system malfunctions.[12]

Moreover the "technological culture" required of clericals is not restricted to a general computer literacy — which itself is not so meager an accomplishment. If a client comes in wanting to know why a transaction ordered a month ago still hasn't been effected, there is often no downstream office to which the teller can turn for information. With less back-up to their operations, clericals must have an understanding of bank accounting flows and of the computer system operations.

Abstraction also affects back-office tasks. The remaining processing jobs' accuracy requirements call for a similar extension of intellectual

mastery. It has always been a good idea to give workers some idea of the next processing step; now, that step is itself an entire chain of automatic operations. The correction of anomalies in the accounting departments undergoes drastic change. The complexity of this task is multiplied many times over; training requirements increase as accountants confront the difficulties of computerized processing.

The importance of understanding the firm's system, in both the operating procedures and the processing steps these procedures trigger, calls for a new and broader type of training. Previously, it was by the successive apprenticeship of several departments that upwardly mobile personnel learned most of their banking. Now, experience cannot suffice, as the critical operating procedures have been internalized in the computer system.

Interdependence — The third feature to emerge as critical at higher levels of automation is the synergy created by the interdependence of tasks.

Recall the problems entailed by the elimination of the processing chain. There is usually no longer anyone "down the line" to pick up errors or to respond to queries. The sequential form of dependence has been all but eliminated; it has been superseded by a new and higher form of interdependence we might call "systemic."[1]

The sequential dependence exemplified in the processing chain posed its own managerial challenge — coordination of discrete tasks, much like the problem of assembly-line balancing. The new, more systemic, network interdependence takes this challenge to a higher plane. It allows for no easy decomposition of tasks, but on the contrary, demands ongoing and flexible integration of the hitherto distinct functions of operations, systems design, and training.

The reciprocal nature of this interdependence in operations is exemplified in the reliance on common databases. Users thereby become dependent on other users' data input accuracy. On another level, "social skills" allowing for effective teamwork become more important.

Systemic interdependence also encompasses the ongoing cooperation of system users — operations — and system designers: this cooperation has become critical to operations efficiency. New application programs to deal with new products are constantly being generated. This increased subsystem flexibility can only realize its potential if there is active cooperation between operations and support staffs to assure that the new procedures cover all contingencies and that they are rapidly debugged. Many computer-intensive operations are thus finding it more efficient to relocate their applications programmers within the user departments.

This new level of system flexibility also calls for more, and more flexible, training programs. On-the-job training of new employees by their experienced colleagues is being supplemented by more theoretical pro-

grams, and these programs are designed to respond to the rapid introduction of new applications. Systemic interdependence thus also encompasses the closer cooperation of operations and training functions. The "life-long learning" idea is not just another passing fad; it reflects the changing nature of technology.[14]

The New Skills Challenges

The banking case points to three clusters of new or enhanced job requirements intimately associated with the more advanced technology: responsibility-for-results, abstract mastery, and systemic interdependence. Depending on their circumstances, other occupations or industries may, may not, or may not yet, reflect these changes. But in any context the effectiveness of Operations and Human Resource management policies depends on the "fit" between these policies and the technology trends in these three "dimensions."

Ignoring these qualitative dimensions can lead to the adoption, consciously or unconsciously, of inappropriate "benchmarks" in the evaluation of skill requirements."[15]

- If the responsibility benchmark is responsibility-for-effort, resonsibility-for-results will be ignored. The steel industry had to confront this issue as it automated; it became obvious that production operators' responsibility for assuring operations' continuity was a greater productive contribution than the craftsmen's traditional responsibility for careful parts machining.
- If the benchmarks are all jobs calling primarily for "concrete" manual skills, the system will undervalue more abstract tasks. Some office jobs, usually staffed by women, seem to have been undervalued in this way, when menial physical exertion has been valued above routine mental effort.
- And if the system interdependence is such that a sustained integration of learning and doing seems necessary, the assumption that skill requirements can be deduced from job assignments may have to be jettisoned or profoundly modified in favor of a system in which wages reflect skills acquired rather than the skills required for the particular job currently occupied.

It is important, moreover, to understand the profound, but perhaps inescapable, managerial challenges that the new skills pose. If automation does call for these new qualities of work, the future will demand some important rethinking of current managerial approaches.

- Old as management's wish for more responsible operators may be, the recognition of responsibility-for-results is not without posing considerable problems.

How, for example, are we to incorporate responsibility into job evaluation systems? The example of the steel industry's collective bargaining agreement is enlightening: its measure of job responsibility is simply in dollars of potential damage to materials or number of lives. But given how difficult it is to identify individual responsibility in modern, complex process, implementing such a criterion requires a reasonable degree of consensus. And that may only be possible in a context of sustained labor/management cooperation.

To the extent that automation calls for recognition of the heightened importance of worker responsibility, it seems therefore to also call for changes in labor/management relations. But recent articles by R. Walton ("From Control to Commitment in the Workplace," *Harvard Business Review*, March-April 1985), E. E. Lawler and S. A. Mohrman ("Quality Circles after the Fad," *HBR*, January-February 1985), and B. Reisman and L. Compa ("The Case for Adversarial Unions," *HBR*, May-June 1985) all show how difficult it is to trace a route from here to there. The key sticking point is perhaps the ambivalence of any labor/management interaction, an ambivalence that is due to the inevitable precariousness of the convergence in these stakeholders' interests. The challenge is then in learning how to sustain cooperative efforts when there is a continual risk of divergence of interests.

- The challenge to management posed by the more abstract tasks is double, reflecting distinct problems relative to the abstraction of the "means" and of the "ends" of people's work.

First, when the "means" are computer-based, learning becomes less rote and more intellectual, and training has to become more general and scientific. We are thus witnessing the generalization of new mental disciplines involved in procedural thinking and broader spans of cognitive, problem-solving skill. Workers' attitudes will have to evolve; so too must management's tendency to define training needs overly narrowly.

These new means of work will also require some adaptation of software, equipment, and environment to satisfy basic ergonomic criteria. It takes some time — and debate — for those new criteria to become clear.

But, and this is the second and complementary challenge of abstraction, the effective use of these "abstract" skills is conditional upon successful adaptation to the likelihood that abstraction of the "ends," or goals, of work will encourage job boredom.

Responsible now not for a discrete, tangible operation, but for much less obvious objectives like process continuity, database integrity, and customer satisfaction, the tellers, clericals, and operators in automated settings can find it difficult, from their vantage point, to identify these task goals as their own, to make them sufficiently concrete to sustain interest and motivation.

A partial solution may be to instill a sense of professionalism and "ownership." But some activities are so mundane that such approaches may be

impossible, in which case work-time reduction might be an important part of the solution.

- The management of systemic interdependence poses a triple challenge to traditional policies.

First, the perennial tendency of functional departments to become fiefdoms will become more costly, as interdepartmental cooperation becomes increasingly central to competitively successful implementation of new technologies.

Second, nurturing the identity of the work-group will assume a progressively greater importance. This means that as automation progresses, turnover in low-level clerical positions will become more, not less, expensive in lost operations efficiency and lower quality of service.

Third, as the form of interdependence shifts toward the systemic, we should expect the basis of financial incentives for results to shift from the individual (piece-rate) to the group (team bonuses) and to the business unit (profit-sharing). But group bonuses can run counter to our individual-oriented sense of justice. The challenge here is to balance the individual's needs for self-expression and the group's functional role.[18]

Conclusion

It is clear that the real diversity of automation's skill effects, the difficulty of predicting them, and the costs of not correctly anticipating them, all militate in favor of very careful assessment efforts.

The first lesson of the banking case is thus that a careful assessment of the qualitative dimensions of what we call "skill" — type of responsibility, degree of abstractness, nature of interdependence — will prove valuable. And examples abound to indicate that these dimensions should be examined in any industry.

But if, as is usually the case, the assessment of some automation project's impact on skill requirements is clouded by uncertainty, then management needs a guiding assumption.

The banking example would suggest that the most useful guiding assumption to bring to the difficult task of skill requirements assessment is that optimal performance generally demands of even low-level jobs:

- more responsibility for results,
- more intellectual mastery and abstract skills, and
- more carefully nurtured interdependence.

The second lesson of the banking example is therefore that we are better off assuming that, more often than not, skill requirements increase with automation.

Indeed, even if, in some situations, technology and market conditions justify the efficiency of low-skill configurations with very short cycle-times,

management should recognize the hidden costs of this solution. Management should be alert to the sacrifices such designs impose in terms of labor motivation as well as in long-run operations flexibility. Careful consideration should be given to the advantages of job-rotation and of programs that give employees real "think-time" — which preserves and encourages their mastery of the process, as well as their involvement in its improvement.

But, if the banking example is any guide and the broader statistical data on the long-run trends in the economy mean what they appear to say, then as a general rule, sustained competitiveness will call for workers capable of mastering new, and in general more demanding, technologies. The myth of de-skilling is dangerous to our long-term economic health.

References

1. On the NC case, Noble has shown the possibility of de-skilling to have been an important motive for the development of NC and has also shown how recalcitrant the art of metalworking really is to the high degree of proceduralization that de-skilling would in fact require: Noble, "Social Choice in Machine Design," in A. Zimbalist, *Case Studies on the Labor Process* (New York, NY: Monthly Review Press, 1979), and Noble, *Forces of Production* (New York, NY: Alfred Knopf, 1984). Williams and Williams, "The Impact of Numerically Controlled Equipment on Factory Organization," *California Management Review* (Winter 1964), pp. 25–34, and Jones, "Destruction or Redistribution of Engineering Skills," in S. Wood, *The Degradation of Work* (London: Hutchinson, 1982), the two studies which offer anything more than case studies, suggest that de-skilling has not been the typical effect of NC. If regional salary data is any guide to skill differentials, it is interesting to note that NC operators are on average paid class A Machinist rates. National Machine Tool Builders Association, *Economic Handbook of the Machine Tool Industry* (McLean, VA: NMTBA, 1982).
2. See the discussion on L. Hirschhorn, *Beyond Mechanization* (Cambridge, MA: MIT Press, 1984).
3. N. L. Flaver and Earl Kincaid, " 'Oops', said the NC Programmer," *American Machinist* (June 1983).
4. See James Bright, "Does Automation Raise Skill Requirements?" *Harvard Business Review* (July/August 1958), where "responsibility" and "education" requirements are described as "increasing or decreasing [or nil]" as one moves to the highest level of automation. See too, a standard text like Roger Schmenner's *Production/Operations Management* (Chicago, IL: SRA, 1981), "Progressing from job shop to continuous flow process, it is more likely that . . . job contents diminish, although 'art' is more likely to be found at either end of the process spectrum," p. 115.
5. See W. Abernathy, K. Clark, and A. Kantrow, *Industrial Renaissance* (New York, NY: Basic Books, 1983).
6. I shall leave aside entirely the problem of automation and employment: the issues of skill distribution and employment levels are largely separable.
7. Field work for this research was conducted in France in 1981 (see Appendix 2). The technological evolution of French banks is quite similar to the U.S. experience, and the current technical levels are, if anything, more advanced in France: for a population of one-fourth the U.S., the French banking system currently conducts a higher number of electronic transactions.
8. See Richard Matteis, "The New Back Office Focuses on Customer Service," *Harvard*

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Business Review (March/April 1979), for the description of the Citibank letter of credit department's parallel evolution.

9. See J. Bright, *Automation and Management* (Boston, MA: Harvard Business School, 1958).
10. There are some important degress of freedom here for astute managers to recruit programmers in-house so as to create a computer services department with the intimate acquaintance of processes that only former operators can have.
11. Earl Wiener, "Beyond the Sterile Cockpit," *Human Factors* (February 1985), p. 83.
12. See Shoshanah Zuboff, "New Worlds of Computer Mediated Work," *Harvard Business Review* (September/October 1982); and B. A. Sheil, "Coping with Complexity," Palo Alto Research Center, Xerox, 1981.
13. Or, following Thompson, "reciprocal," *Organizations in Action* (New York, NY: McGraw-Hill, 1967).
14. See Larry Hirschhorn, op. cit.
15. These benchmarks may be implicit or, for organizations with job evaluation plans, explicit; in either case inappropriate points or reference will lead to suboptimal results.
16. It would therefore seem that technical change itself encourages the shift documented by George Lodge in *The New American Ideology* (New York, NY: Knopf, 1975), or, in a comparable endeavor, by Roberto Unger in *Knowledge and Politics* (New York, NY: Free Press, 1975), from "Lockean individualism" to "communitarianism."

Appendix 1

There is a striking parallel between, on the one hand, the discrepancies between management expectations and realizations of the kind mentioned at the beginning of this article, and, on the other, the discordance between:

- a venerable, multi-stranded tradition in social and economic theory which posits a long-run, average tendency of technical change to reduce skill requirements; and
- the more "common-sensical" view that real-world technical change is usually accompanied by skill increases.

The lineage of the "de-skilling" tradition is long:

- Adam Smith, in *The Wealth of Nations*, on pin manufacturing divided into 18 distinct operations;
- Karl Marx, in *Capital*, takes up Ure's critique (*Philosophy of Manufacturers*) of machinism that reduces the worker to "a mere fragment of a man";
- major studies on the 1920s and 1930s, on destruction of crafts in U.S., like the *National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques* (Works Progress Administration, 1940);
- James Bright, *Automation and Management* (Boston, MA: Harvard Business School, 1958), and a summary of some key parts in "Does Automation Raise Skill Requirements?" *Harvard Business Review* (July/August 1958);
- Harry Braverman, *Labor and Monopoly Capitalism: the Degradation of Work in the Twentieth Century* (New York, NY: Monthly Review Press, 1974), who relies on Bright;
- Stanford's Henry Levin and Russell Rumberger "The Low-Skill Future High-Tech," *Technology Review* (August/September 1983).

The basic thesis is well summarized by Bright's self-explanatory diagram.

If, as the de-skilling tradition would have it, powerful forces assure the reduction of skill requirements, then surely some aggregate tendency should be manifest in the occupational data.

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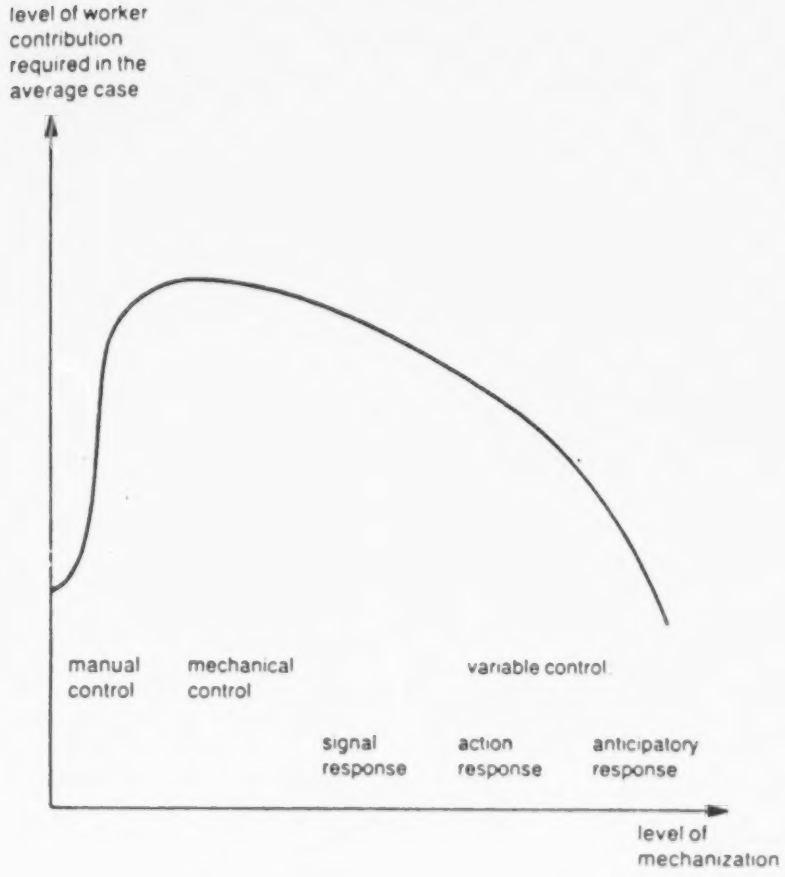
James Bright's assessment of how total contribution required of operators may vary with levels of automation



Source: James Bright, "Automation and Skill," *Harvard Business Review*, (July/August 1958). Reproduced by permission.

What, then, do the U.S. data tell us? Bluntly put: very little. Which explains why the optimistic, up-grading thesis has received, for all its plausibility, so little scholarly support.

It is possible, however, to isolate the conditions that would be required for the de-skilling hypothesis to be true—and to show them to be completely implausible.

Consider the following table that reproduces the Census estimates of occupational structures in 1900 and 1970 for the total employed population (over 14 years old).

Employment Structure of the Total U.S. Labor Force (%)

	1900	1970
White-collar workers		
Professional, technical	4 3	14 5
Managers, officials, proprietors	5 8	8 1
Clerical	3 0	17 8
Sales	4 5	7 1
Manual and Service workers		
Craftsmen, foremen	10 6	13 9
Operatives	12 8	18 0
Laborers (excl. farms, mines)	12 5	4 7
Private household workers	5 4	1 5
Other service workers	3 6	11 3
Farm workers		
Farmers, farm managers	19 9	1 8
Farm laborers, foremen	17 7	1 3
Total	100.0	100 0

Source Historical Statistics, Series D182-232

We can now use some index of the relative skill of each category to calculate an average skill level of the whole labor force in each year. Unfortunately, a reliable index is hard to find. The best available index is perhaps that generated by the U.S. Employment Service's *Dictionary of Occupational Titles*. In it we can find an estimate of the general skills required to perform at an average level of proficiency. Unfortunately again, the survey on which it is based does not go back to 1900, and readers have been cautioned against comparing the scores in different years. We can, however, take the scores in one intermediate year, say 1950, and use them to rank the average skills of each occupational category in both 1900 and 1970. This assumes that the relative skills of each occupational category have not changed over the period. Accepting this assumption only provisionally, we can calculate a comparable index of average skill level for 1900 and 1970: it increases from the equivalent of 10.3 years schooling required in 1900 to 11.2 in 1970.*

Thus, the effect of the changing occupational structure — as distinct from the effect of changes in the component individual jobs — is clearly an upgrading one. And significantly so. Under these conditions the plausibility of the de-skilling hypothesis can only be sustained if we believe that skill requirements for individual jobs within each occupation have undergone a systematic downgrading sufficient to more than compensate for this compositional upgrading effect.

*I have calculated these results from the data in R. Rumberger, "The Changing Skill Requirements of Jobs in the U.S. Economy," *Industrial and Labor Relations Review*, 34/4 (July 1981).

The implausibility of that idea is manifest when we think not of this or that particular example of de-skilling — they clearly abound, and may call for policy remedies — but of the whole gamut of occupations. Indeed, Kenneth Spenner ["Deciphering Prometheus: Temporal Change in the Skill Level of Work" *American Sociological Review* Vol. 48 (1983)] has recently reviewed all the major studies on post-World-War-II skill trends. He found *not one* to show a long run de-skilling trend of individual occupations; most show a small but clear net upgrading of both the average occupation and the labor force as a whole.

Of course, the autonomous role of technology in these changes is difficult to measure. To some extent, technological choices may reflect the availability of a more educated work force. But the data show at least that automation has generally been accompanied by increases in skill requirements.

So why does this divergence between "common sense" and serious theoretical reflection persist?

Part of the difficulty lies in the tendency of such debates to polemical excess. Protesting the misfortunes of a relative minority, advocates of policy intervention are naturally wont to exaggerate in their depiction of the extent of the problem.

Furthermore, the tradition of thought most eloquent in its critique of de-skiling from a managerial point of view — the sociotechnical systems approach [see, for example, W. A. Passmore and J. J. Sherwood, eds., *Sociotechnical Systems: A Source Book* (San Diego, CA: University Associates, 1978); L. E. Davis and J. C. Taylor, *Design of Jobs* (Santa Monica, CA: Goodyear, 1979)] — has emphasized the wide range of managerial discretion in work design at *any* level of automation. They have, therefore, had little impact on the debate concerning the direction of changes in the optimal work design as the level of automation rises.

But for another part, the optimists and the pessimists seem to mean different things by the term "skill": the pessimists seem to have in mind the dignity of the craftsman, while the optimists seem to focus principally on educational and technical requirements.

These ambiguities cannot but influence managers when they grasp for a general sense of where automation is leading their Operations and Human Resource policies over the longer run. To what framework can they turn? What notion of skill requirements can help them identify the new challenges posed by automation?

Economists are of little help. For many decades, orthodox economists considered the issue outside their domain. Since the Chicago-led "human capital revolution," they have come to think of skill as the amount of human capital accumulated in training. In this perspecitve, wage-rates are determined primarily by the scarce resources invested in acquiring human capital.

This framework has the attraction of a certain rigor. There are obviously other factors, social and institutional, that play their part in setting wages (and heterodox economists, by highlighting these factors, have contributed to a more realistic appreciation of wage determination). But the "dull compulsion" of economic, market forces is difficult to deny.

The economic framework is necessarily inadequate, however, when we want to identify the qualities that the training activity (or any other element of Human Resource policies: selection, promotion, and so fourth) is designed to elicit.

The search for a framework for thinking about these qualititive issues reveals several alternatives. Some are excessively narrow, like those that reduce skill to the "autonomy" of the ideal craftsman, or to a generic "information processing complexity," for example.

Others, like job evaluation systems or the psycho-sociological research literature, permit great nuance but are too flexible to provide any general sense of direction since they require extensive adaptation each time focus shifts to a new set of jobs.

One of the major difficulties in formulating a useful characterization of automation's impact on skills seems therefore to lie in the very notion of skill. The persistence of the two currents of thought, optimists and pessimists, seems to indicate that the reality is more complex than either admits.

Appendix 2

The analysis reported here is based on my 1981 dissertation on automation and work in French banks.

Apart from analysis of the available literature, especially French but also U.S. and British, its principal database comes from four months full-time field work in one of the four French banks classed in the top ten worldwide by balance-sheet.

Hundreds of interviews with managers at all levels were complemented by one month's participant-observation as a teller in two branches at different stages of automation.

There are a number of differences between French and U.S. banks. Apart from the relative concentration of the industry and the weight of the three banks nationalized in 1945, French banking has a very strong collective bargaining agreement, making banking jobs relatively attractive and assuring low turnover in all but a handful of clerical positions.

Far from limiting the generality of the lessons drawn, the particularities of French banking serve to highlight the issues that are the focus of this article.

2

TECHNOLOGY AND DESKILLING: THE CASE OF FIVE PRINCIPAL TRADE AREAS IN NEW SOUTH WALES

D.J. DAVIS

D.J. Davis, 'Technology and deskilling: The case of five principal trade areas in New South Wales', *New Technology, Work and Employment*, vol. 3, no. 1, 1988, pp. 47–55.

This article summarises features of the current debate over whether new technology upgrades or downgrades skill and knowledge requirements and reports on how 1,700 tradespeople (craftspeople) interviewed in 1983–85 in NSW, substantially reported an upgrading effect.

The primary purpose of this article is to report on how a significant representation of tradespeople (craftspeople) in New South Wales, Australia perceived the direction of impact of technological change upon their job's skill and knowledge requirements. The article first attempts however to describe the debate currently taking place over the existence or otherwise of technological deskilling. Given the divergence of this debate there should be some interest in how 1,700 tradespeople in five principal trade areas perceive the job requirements effects of technological change taking place between 1974 and 1985. The author also supplemented the data from this source with data from visits to a small number of manufacturing firms in Western Sydney.

Readers should note that the report focuses on technology's effects on the nature of jobs, not on its effects on the number. Furthermore the data concerning the impact of technology upon the skill and knowledge requirements of tradespeople's jobs were not collected for a major study on technology but for identifying a possible factor amongst others that might help explain persons' staying in or leaving their trades. Therefore the findings given below might be considered as preliminary and, because the study was not designed to explore the technology issue in depth, raise and leave several important questions about the interface between technology and the workplace unanswered. Nevertheless the findings and the questions they raise should be of interest to persons concerned in the technology impact debate.

The major finding of the report is that the tradespeople surveyed perceive insignificant levels of deskilling occurring but considerable levels of upgrading. In itself the evidence cannot refute either polarisation theories or speculation of longer term deskilling or diminution of number of skilled job opportunities. Nevertheless it shows that the technology and labour process interface is complex and suggests that technology is not as immediately deterministic as some writers propose. It may also suggest that the capitalist system contains an endogenous mechanism at work at plant level that checks the technological deskilling process. This endogenous factor is competition based on quality as well as quantity, which, to attain the finest edge requires cooperation between

labour and capital in the introduction of new technologies.

Another finding indicates a need for considerable recurrent education as new technologies are introduced.

The background debate

Discussants of the impact of new technology upon skill requirements tend to argue on at least two planes. One is over the recognition or non-recognition of new technologies as a labour exploitative weapon in a competitive context; the other is over the degree of technological determinism in either the upgrading or downgrading of worker skills.

Braverman, Dickson and Reinecke see technology in terms of a contest for industrial and social control[1]. Braverman treats technology as an endogenous factor within a strategy of maximising profit at the expense of workers. Dickson sees the dominant technological approach in terms of the prevalent social structure. Reinecke in Australia sees technology as a deliberate managerial program of deskilling. All three are not only overtly recognising an ideological context but are necessarily deterministic in that they see technology as a weapon to weaken the bargaining position of labour through deskilling. Braverman points to the routinisation of work strategies of Babbage and Taylor to advance his case, arguing that their writings have become the gospel of good capitalist management.

Other discussants who do not necessarily admit the notion of struggle between capitalism and labour for control of labour may nevertheless lean to some degree of technological determinism.

The school that Penn calls the post-industrialist (for example, Bell, Harris and perhaps to a more qualified extent various members of OECD and Peitchinis) come from a human capital tradition that associates productivity with education and that believes the sophistication and complexity of new technology requires higher levels of education[2]. This school believes the upgrading occurs by an elimination *on balance* of routinised and lower level skilled jobs and a compositional shift of the workforce towards service and 'brainpower' type jobs. It acknowledges that in this process there will be losses of some skilled jobs and problems of structural readjustment.

Views of other writers range between being optimistic and pessimistic according to their degree of sensitivity to such factors as the time horizon of the technological change, the type of labour market the technology is affecting, the balance between technology's direct effect on skill requirements of workers using the technology and its wider effects on change to labour force composition, and the writer's assumption of technological determinism.

Senker for example is generally optimistic concerning upgrading in the short-term but is less confident about the long-term. His studies of craftsmen in engineering maintenance in UK show upgrading and widening of skill requirements as machinery becomes more complex, but he admits that the longer term consequences of the introduction of diagnostic equipment may be to downgrade skills[3].

Johnston considers that discussion of the results of technology is clouded unless one specifies the type of labour market[4]. He argues in the context of labour market segmentationist divisions that technology downgrades skills in the subordinate primary and secondary labour markets but not necessarily in the independent primary. He also believes the analysis needs to look at impacts on the informal labour sectors as well as the formal.

Rumberger, analysing at US national aggregate levels, draws a distinction between direct technological effect on specific occupational skill levels and technology's effects on occupational composition of the workforce in general. He has consistently measured the effect of the former as downgrading and the latter between 1960 and 1976 as upgrading—with over that period the latter effect outweighing the former[5]. However his later work is more depressing as he now predicts downgrading effects from both factors[6].

A significant amount of the literature now challenges the notion of technological determinism. Writers may still be acknowledging technology's deskilling effect, be concerned about it, even feel it is likely, but question *whether even under capitalism* it must necessarily occur. Senker for example points out that there seem to be different employer traditions.

German employers in engineering for instance seem less likely than the British to use technology to deskill their workers[7]. Other sources show differences between

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countries and differences between firms within countries[8]. Barry Jones, Australian Minister for Science, claims nations have and should make a choice[9]. Rumberger also acknowledges that the use of technology does not have to be predetermined[10].

Writers tend to vary on how much they see the need for adoption of anti-deskilling technological options requiring an interventionist approach (say from government and/or national trade union bodies, for example Noble, ETUI, Gough and Stiller, and Walton[11]) and how much they see the adoption developing 'naturally' by shifts (caused by technology) in balance of management: worker power (see for example Wilkinson, Penn, Littler and Salaman, and Clark et al. [12]). Rosenbrock in contrast argues the need for an interventionist approach at the level of the social consciousness[13]. He feels that technology's deskilling process is not the product of a technological, economic or ideological determinism but of a scientific attitude that treats human ability as inferior to the machine.

As one can see the debate is still a very divergent one and one reason accounting for this has been the difficulty of standardising the occupational context of aggregate empirical studies[14] and of knowing how much to generalise from the findings of smaller case study work. Rajan in his study of the effect of technology on employment in financial institutions also points out the subjectivity involved in balancing possible loss of job specific skills against possible gain of diagnostic ones[15]. The differences and difficulties in methodology in the empirical studies are comprehensively discussed by Spenner[16]. While the empirical studies continue to have problems different theoretical explanations and speculations will continue to abound.

Context, design and methodology of the study

This report is part of a much larger study embracing several aspects of New South Wales tradespeople in the labour market, educational, industrial training and social contexts. It was carried out by the Centre for Research in Education and Work (CREW) at Macquarie University for the Technical and Further Education Council of New South Wales and the Evaluative Studies Committee of the Commonwealth Tertiary Education Commission (CTEC) and was funded by CTEC[17]. The study was mainly prompted by concern expressed in 1981 over a possible shortage of qualified trade labour to sustain the growth in industrial development then evisaged. In this regard it should be noted that the skilled trades qualification is still the single most important qualification for the workforce, especially the male. In 1981–82 males with trade level qualifications formed 27.0% of the total and 52.6% of the qualified (those with post-school qualifications) full-time employed workforce[18]. Apprenticeship was and still is the chief avenue for achieving that qualification.

The study's section on technology asked tradespeople to nominate whether changes in technology had *upgraded*, *downgraded*, or *not changed* the *knowledge* and *skill* requirements of their current trade job or if no longer in a trade job of the trade job they last occupied.

The breadth of the study limited the inquiry to the examination of three broad areas of technological change; changes in processes, machinery and materials. Hence respondents were not asked to describe the impact due to specific technologies in the given trade areas though one knows that these include to varying degrees within each trade change from on-site construction to on-site assembly on building sites, from use of metal to plastic materials, from metal to chemical fasteners, from mechanical to electronic controls, from conventional to NC machine tools, from reparable to throw-away components and so forth.

The persons surveyed undertook apprenticeships in either the metal fitting and machining, carpentry and joinery, metal fabrication (boilermaking and welding), automotive mechanics or electrical fitting or mechanics trades. The membership of these trade areas makes up some 47% to 50% of the total New South Wales apprenticeship membership. Those surveyed were also drawn from three cohortal populations of tradespeople who in either 1974 (Cohort One) 1977 or 1979 (Cohort Two) or 1982 or 1983 (Cohort Three) undertook the third and final year of the formal education component of their courses in technical and further education colleges located in either the Sydney, Hunter or Illawarra regions. These three regions include the industrial base of New South Wales and contain some 76% of total

New South Wales apprenticeships. New South Wales itself contains some 35% of Australian apprenticeships and has the largest single state apprenticeship intake. Accordingly the regional and occupational areas surveyed in the study represent a significant component of the Australian apprenticeship system and of the skill source of the Australian male workforce.

Respondents within each trade group are neither homogeneous in terms of type of industry nor size of firm employed nor skills and knowledge most utilized. The study's intra-trade sectoral analysis helps overcome in part some of the difficulties this lack of homogeneity causes, but in the electrical trades the differences between those employed in electrical contracting and other electrical areas are so marked that the two are always reported in this study as two separate trade areas. The profile of electrical contracting is mainly associated with that of the building industry whereas that of the other electrical employment is mainly associated with that of electrical power generation and distribution and manufacturing. Members of the former may also have specialised more in the area of electrical mechanics and the latter more in electrical fitting, though both possibly did common core subjects.

An important factor to be borne in mind in the interpretation of findings is not only the difference in the nature of work between trades and, within trades, between sectors of employment but differences in the size of firm employed. Differences in the size of firm can influence the technological impact through differences in knowledge of and resource capabilities to adopt and adapt new technologies, the relationship between workers and management and the capacity to provide on-the-job or off-the-job training. Bearing this factor in mind therefore it is propitious for one to know that carpentry and joinery, motor mechanics, and electrical contracting are what might be called the smaller firm trades, that is, employment of members of these trades concentrates in small firms, while metal fitting and machining, metal fabrication and electrical NIC (not in contracting) are larger firm trades, that is, employment of members of these trades concentrate in large firms.

The data reported in this paper were derived by questionnaires mainly filled in at face to face interviews in the homes of respondents, though 20% were filled in by respondents themselves and sent back through the mail.

The oldest cohorts interviewed (Cohort One—1974) were in the workforce as qualified tradespersons for eight to ten years when interviewed. (As an apprenticeship takes four years to complete, third-year apprentices in 1974 would have qualified as tradespeople from the beginning of 1976.) Many of the members of the youngest cohort were still not qualified at time of interview. Members of the oldest cohorts were aged in their late twenties and members of the youngest were just beginning or about to begin their twenties.

For logistic reasons trade groups were interviewed at different times—beginning in late 1983 with electrical tradespeople and finishing in March 1985 with metal fabrication and automotive mechanics.

The proportion of respondents to the sample surveyed varied considerably by trade being in descending order: 47.5% for electrical, 44.6% for fitting and machining, 30.6% for carpentry and joinery, 25.7% for automotive and 25.1% for metal fabrication. In all trades and all cohorts the number of respondents was above 10% of the total population of apprentices in the given trade, year and region. The level of percentage responses to the sample was mainly affected by difficulties in tracing tradespeople who had moved from the address given to TAFE in the third year of their apprenticeship rather than from any lack of cooperation from those approached.

The technological responses were analysed by simple comparisons of proportions of tradespeople reporting upgrading, downgrading and no change effects. Unfortunately the proportion of 'no change' respondents includes both those who experienced no technological change as well as those who experienced technological change but felt here had been no requirements change. Nevertheless this restriction does not affect comparison of upgrading and downgrading proportions, and a combination of both gives a minimal impression of the extent of technological change.

In the major study the direction of impact was compared by trade, by cohort and then within trade by industrial sector of employment and by cohort[19]. However to simplify the presentation and argument only the first two levels of comparison are given in tabular detail in the paper. Findings from intra-

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trade comparison are mentioned in the text if the findings from the other two levels require highlighting or qualification.

The statistical significance of the tabular data was measured by chi-square values and degrees of freedom. The use of the term 'significant' in respect of the statistical findings means they are statistically significant at the .05 level and 'highly significant' at the .01. However a 'finding' may also be determined or corroborated by the occurrence of a pattern or a trend across tables even though within each table it is not statistically significant.

The total number of cases in each analysis is given at the bottom or side of each table.

In addition to the data provided by interviews of trades people in their homes, the author collected data from visits to four firms in a manufacturing belt of Western Sydney. One firm was a small enterprise engaged in making moulds, the other three firms were large, one producing car components, another metal chains and another, tobacco products. All firms visited had recently adopted numerical control equipment. The small firm was one of the first in Sydney to also use the CAD equipment.

The visits were not part of the original study but were prompted by a need to see whether the data the tradespeople gave were consistent with what could be observed in the work place. The visits were more to gain impressions than to scientifically collect data.

The findings

In short the findings suggest that the technological change is having:

1. Foremost, far more upgrading than downgrading effect; more overall impact on knowledge than skill requirements; more upgrading of knowledge than of skill requirements and more downgrading of skill than of knowledge requirements; and more impact on older than younger workers.
2. A highly differentiated effect in different trades and industries—with upgrading requirements being greatest for motor mechanics and for electrical fitters and mechanics in power generation and distribution industries and downgrading being greatest for carpenters and joiners in building and
3. A differentiated effect by area of technology with most impact being in machinery and least in materials. However this varies by trade area with materials tending to have a greater impact than have other areas on knowledge requirements for carpenters and joiners.
4. No perceived effect for a large proportion (some 40% to 50%) of trades people, either because there is little technological change occurring or because what change that does occur doesn't affect skill or knowledge requirements.

Table 1: Perceived impact of technological change on knowledge requirements to do job by cohort and by area of technological change (Percentage of respondents in given cohort)

	Cohort			
	1974	1977/79	1982/83	All
A Changes in processes Effect				
Increase	62	59	51	56
No change	34	38	44	40
Decrease	4	3	5	4
B Changes in machinery				
Increase	63	59	58	60
No change	34	37	39	37
Decreased	3	4	3	3
C Changes in material				
Increase	59	54	46	52
No change	40	43	52	46
Decrease	1	3	2	2
N =	487	553	659	1709

The findings are described in more detail below under the headings changes in knowledge and change in skill requirements and impressions from industry visits. Unless otherwise stated the word 'impact' in this section refers to the *combined* proportions of respondents reporting upgrading or downgrading effects.

Changes in knowledge requirements

1. An upgrading of knowledge requirements was far more commonly reported than downgrading. Between 52% and 60% of respondents stated that changes in processes, machinery, and materials had increased the knowledge required for carrying out trade work. Between 37% and 46% stated that there had been no change; while only between 2% and 4% stated there had been a decrease (see Table 1 for more detail).
2. The perceived upgrading of knowledge

Table 2: Perceived impact of technological change on knowledge requirement to do job by trade and by area of technological change (Percentage of respondents in given trade)

	Trade Area (1)	(2)	(3)	(4)	(5)	(6)
A Changes in processes Effect						
Increase	50	46	48	75	71	42
No change	47	46	46	24	29	56
Decrease	3	8	6	1	0	2
B Changes in Machinery						
Increase	59	45	54	76	67	50
No change	40	45	46	23	32	49
Decrease	1	10	6	1	1	1
C Changes in materials						
Increase	45	53	37	60	66	48
No change	55	40	60	40	34	49
Decrease	0	7	2	0	0	3
N =	363	356	259	322	303	106

Code of Trade Areas
(1) Fitters and machinists
(2) Carpenters and joiners
(3) Metal fabricators
(4) Motor mechanics
(5) Electricians NIC (not in contracting)
(6) Electrical contractors

Table 3: Perceived impact of technological change on skill requirements to do job by cohort and by area of technological change
(Percentage of respondents in given cohort)

	Cohort 1974	1977/79	1982/83	All
A Changes in processes Effect				
Increase	48	44	41	44
No change	43	49	50	47
Decrease	9	7	9	9
B Changes in machinery				
Increase	49	45	46	47
No charge	43	46	43	44
Decrease	8	9	11	9
C Changes in materials				
Increase	43	41	38	40
No change	51	52	57	54
Decrease	6	7	5	6
N =	497	553	659	1709

requirements and impact of change increased with the length of time out in the workforce.

3. The perceived direction and amount of change varied substantially between trades (see Table 2):

- combined cohorts of *motor mechanics and electricians NIC* (not in contracting) consistently reported the greatest amount of upgrading of skill requirements and greatest impact of technological change in all areas of change (processes, machinery and materials). (This pattern also held true for each cohort in respect of changes in processes and materials and for each cohort except the 1984 in respect of changes in machinery.)
- *electrical contractors* reported the least impact due to changes in processes and machinery and the least increase in requirements due to changes in processes
- *carpenters and joiners* reported the highest losses of knowledge requirements in all three areas
- the level of increase of knowledge requirement in *the metal trades* fluctuated between the others, with fitters and machinists reporting a greater increase in knowledge requirement than metal fabricators.

Changes in skill requirements

1. An upgrading of skill requirements, though to a lesser extent than an upgrading of knowledge requirement, was far more commonly reported than a downgrading. Between 40% and 47% of respondents stated that changes in processes, machinery, and materials increased the skill required for carrying out trade work. Between 43% and 54% stated that there was no change, while between 6% to 10% stated that there was a decrease (see Table 3 for more detail).
2. In all areas of change and in all cohorts levels of upgrading were lower and levels of downgrading higher for skill than for knowledge requirements.
3. The cohortal pattern for skill requirements is similar to that of reported knowledge requirements. In all areas of change (with the exception of the impact of machinery change on the 1977/79 cohorts) the impact and the requirements in skill increase the longer the period since entering the workforce.
4. With some modification the pattern of variation by trade tends to be the same for both skill and knowledge requirements.

Table 4. Perceived impact of technological change on skill requirements to do job by trade and by area of technological change
(Percentage of respondents in given trade)

	Trade Area					
	(1)	(2)	(3)	(4)	(5)	(6)
A Changes in processes Effect						
Increase	37	25	43	65	57	36
No change	56	53	51	31	41	48
Decrease	7	22	7	4	2	6
B Changes in machinery						
Increase	42	29	43	69	57	37
No charge	48	54	46	25	40	56
Decrease	10	17	11	6	3	7
C Changes in materials						
Increase	33	31	37	53	53	31
No change	64	53	60	42	45	64
Decrease	3	16	3	4	2	5
N =	363	356	259	322	303	106

Code of Trade Areas
(1) Fitters and machinists
(2) Carpenters and joiners
(3) Metal fabricators
(4) Motor mechanics
(5) Electricians NIC (not in contracting)
(6) Electrical contractors

- the *motor mechanics and electrician NIC* trade groups consistently reported the greatest increase in skill requirements in all areas of change in all cohorts.
- the *electrical contracting* trade group reported the least impact due to changes in processes and machinery and equally with fitting and machining the least impact due to changes in materials. Electrical contracting also reported the least increase in skill requirements due to changes in materials (see Table 4).
- the *carpentry and joinery* trade group consistently reported the highest loss of skills in all areas of change in all cohorts. The greatest loss is due to changes in processes. The reported loss of skills in the 1974 cohort (26.7 per cent) due to changes in processes equalled the reported gain, the only time when the reported gain in any trade in any cohort in any area of change did not exceed the reported loss.
- again the level of upgrading within *the metal trades* fluctuated between the others. However in skill requirements in contrast with knowledge requirements (where fitting and machining reported the greater increase) metal fabricators reported the greater increase.

Impressions from industry visits

In general the impressions gained from the visits to the four firms were consistent with the above findings. The four firms highly valued their trade labour both because they kept old technologies on with the new and needed tradesmen to maintain the latter, but also because they used the skills of the tradesmen to adapt new technologies to the existing workplace. It also makes economic sense that employers would value this labour because they have just spent resources in its acquisition through apprenticeshp training. They are not likely therefore to deskill this asset.

Discussion

These preliminary findings suggest that the impact of technology on knowledge and skill requirements in jobs is far from deterministic—at least not in the short term and not to all labour affected.

The apparent contradiction between the Braverman idea of technology's 'deskilling' effect and the tradespersons' perception of the opposite suggests the existence of a very complex relationship between technological change and the labour force and that

- the study might be 'spotlighting' one facet of the impact as it effects an 'elite' group of workers, and not necessarily the workforce as a whole (in which case this could be the sign of a polarization effect and consistent with the Braverman thesis).
- employers are ensuring by the way they bring new and old technologies together with skilled workers that they minimise the wastage of the training in which they might have invested in those workers and/or
- the new technologies in use alongside the old are in fact in general skill demanding and challenging rather than deskilling.

However another factor which needs to be borne in mind, and which has been mentioned by writers such as Salaman and Wilkinson, is that of the need for cooperation of labour in order to obtain the full competitive effect on new technology. A shift in the balance of competition from pure

competition at lowest cost per unit to lowest cost per quality unit has introduced cooperation of management and labour as an endogenous factor in the impact of technology on the labour market. The visits to the Western Sydney plants showed, for example, that without such cooperation accompanying human resource development and changes to working conditions new technology tended to remain idle, or at most be only an adjunct to the production process.

If firms could completely replace labour with physical capital then by definition such cooperation is not required, but even in the most automated plants this is not likely. And in reality what seems to have happened to our tradespeople is quite the contrary. The huge percentages perceiving upgrading compared with those perceiving downgrading indicate the need for considerable human resource development.

Perhaps the long run effect of the new technology may be to decrease the demand for skill in the workforce because the new technology is meant to increase labour productivity and, if demand for goods should not increase, then labour might be reduced. However the point where labour displacement might occur may substantially vary with the relative competitiveness of the firms and countries adopting compared with those not adopting the new technology. It could be that it is those firms not adopting the new technologies that witness the displacement of their skilled labour. This study cannot throw light on this point.

If we can take these figures of upgrading at face value, and I believe we can, then they also suggest certain directions for human resource development. They indicate the need for human resource development for new technology to distinguish between skill and knowledge requirements, area and industry of technological change and age of workers.

The data show, for example, considerably more upgrading on knowledge than on skill requirements pointing to the need for an appropriate educational base to be developed in the workers' pre-vocational education. The different impacts in process, machinery and materials technologies and in different industries show the need for a discriminant policy of public guidance or assistance. Finally the greater impact reported by older than younger workers argues more strongly than ever before for the need for adequate recurrent education facilities.

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3

INTERSPHERE AUTOMATION—THE 'FACTORY OF THE FUTURE'

R. KAPLINSKY

R. Kaplinsky, *Automation: The Technology and Society*, Longman, Harlow, Essex, 1984, pp. 93–110.

In Chapter 1 of this book we observed the emergence of crisis in the world economy and pointed to the response of capital which, in recent years, has been to intensify the drive to automation. General Electric, under threat in almost all of its major product areas refers to these automation technologies as the 'factory of the future', while the Japanese activities have been coordinated by the Ministry of Trade and Industry (MITI) which has launched a programme to develop the 'unmanned factory'. In Chapter 2 we noted the underdeveloped nature of much of the (now dated) analyses of automation and offered a three way classification of the concept, based on the historical evolution of the modern enterprise into three spheres of production. Then, in Chapters 3, 4 and 5, we focused on the progress of intra-activity and intra-sphere automation in each of these three spheres, noting that the recent diffusion of electronics into these various activities has given a major impetus to the ease and imminence of the development of the final stage of automation, that is inter-sphere automation. In this chapter we survey the feasibility of this final, complex stage of automation. But before doing so it is necessary to briefly recap the major conclusions of the three preceding chapters on the development of intra-activity and intra-sphere automation in the three spheres of production.

THE PROGRESS OF INTRA-ACTIVITY AND INTRA-SPHERE AUTOMATION: A SUMMARY

In *design* it appears as if automation took a long time to arrive. As recently as the mid-1970s, intra-activity automation, particularly in engineering industries, was largely confined to the use of mainframe computers to assist with design calculations; intra-sphere automation, linking various activities of design, was almost unknown. Only in the electronics industry and the defence – aerospace sectors did we see the existence of embryonic intra-activity automation, and even in these sectors it was only around the mid-1970s that intra-sphere automation became viable (for example in using CAD systems to develop

the 'masks' for integrated circuits). However, in the latter half of the 1970s both intra-activity and intra-sphere automation arrived with a 'bang'.

The supplying industry grew at a phenomenal pace and even in the recession of 1981–2 heady growth rates were maintained as user-firms rapidly appreciated the benefits which this automation technology provided. Thus by the end of the decade systems were already in place offering almost full intra-sphere automation, except for the initial activity of product specification which, by its nature, remained a 'labour-intensive' activity undertaken in consultation with senior management as part of the process of organizing corporate strategy.

In the *manufacturing* sphere there is a much longer history of both types of automation. Indeed one of the first recorded cases of intra-sphere automation goes back to an eighteenth-century grain-mill in America and even more primitive systems almost certainly predate this in other sectors and in other countries. The significant events in this sphere of manufacture, however, occurred in the 1960s and 1970s during which electronic control systems diffused to a wide number of individual activities, ranging from numerical control (NC) tool-cutting devices and transfer lines to robots and automated warehouses. Their significance lies in the ability of electronic systems to reduce lead-times, improve flexibility (for example, in changing machine settings), reduce costs (especially that of labour) and improve quality.

Most importantly, because of their use of a common binary logic, electronic systems offer the potential for mating together various activities. Now although, as we have seen, intra-sphere automation per se is not a new phenomenom in this sphere (eg moving assembly lines), the new electronics-based systems offer the same advantages to intra-sphere automation as they do to intra-activity automation. The critical significance of recent automation technologies incorporating electronics is that whereas intra-sphere automation used to be confined to large-scale mass production sectors (for example, assembly lines in vehicle manufacture) it is now becoming increasingly viable in small-batch production. This explains the significance of existing technological developments such as flexible manufacturing systems and more ambitious ideas as embodied, for example, in Hal-Technology (which will be discussed later in this chapter).

Finally in the *coordination* sphere it has long been noted that even intra-activity automation has been slow to emerge beyond typewriters, dictation machines and photocopiers. But in the late 1970s a variety of new intra-activity automation technologies were developed such as word processors and electronic typewriters, electronic files, small business-computers, intelligent copiers and fax machines. Supplying firms are now (ie in the early 1980s) largely concerned with improving applications software and marketing these single purpose machines, although some are actively beginning to put them together in systems embodying intra-sphere automation technologies. Thus, whilst the development of full intra-sphere automation – that is the integrated, multi-purpose workstation – is still some distance in the future, lesser forms of automation are beginning to emerge such as those systems which store and process information as well as offering word processing facilities. So the appear-

ance of full intra-sphere automation technologies is a matter of time, and the speed of development depends as much on the receptivity of using firms as on the availability of suitable automation technologies.

IS FULL INTER-SPHERE AUTOMATION POSSIBLE?

The process we have recorded reflects a significant speeding-up in the development and diffusion of automation technologies as electronics diffused downstream over the 1960s and 1970s. And as the real cost of electronic equipment continues to decline in the 1980s, as software-development expands (with possibly even 'automated software writing' becoming feasible for certain routines) and as economic pressures inducing automation are maintained, so we can anticipate that the pace and degree of automation in the 1980s will continue to increase, and that diffusion will widen. It is important, however, to be wary of projecting into the future too glibly – as one observer pointed out, if the rate of expansion in the training of scientists and engineers in the USA (following the shock of Russia's launch of its first satellite in 1957) had continued unabated until the 1990s, there would have been two scientists for every man, woman and dog by the year 2000! (Jahoda, 1980). Clearly, therefore, there must be some limits to the advance of automation. Three stand out in importance

Technological impediments to full inter-sphere automation

If we return to the individual activities in each of the three spheres of production (Figures 2.3, 2.4 and 2.5) it is immediately clear that some, particularly in the coordination sphere, can never be fully automated since they depend quintessentially on human decisions. These include strategic decisions with respect to product development, procurement of inputs, and marketing strategies. Whilst in each of these activities the input of human labour can be augumented by automation technologies – for example, the Japanese are hoping to include in their development of the fifth generation computer, a capability for the computers to make certain decisions now made by humans – this human input can never ever be completely phased out. Nevertheless, there is still scope for the automation of a very wide number of activities now involving humans.

Full inter-sphere automation is not, however, only constrained by the absolute necessity to include humans in some key decision-making roles, but it is also held back by the need to develop suitable subsidiary technologies which allow the automation technologies to function efficiently such as sensing and activating mechanisms (see Chapter 2). Similar observations have been made in relation to earlier periods of technological development. Freeman (1974), for example, shows how the move from batch- to flow-production methods in the chemical industry necessitated the development of components such as pumps, compressors, filters, valves, pressure vessels and instruments. Bright

(1957), in his pioneering study of automatic machinery in the manufacturing sphere, believed that automation would require matching developments in materials, production processes, factory layout and design of the product. This reliance on other matching technologies he suggests was not unique to the mid-twentieth century.

> Historical research in almost any manufacturing field shows that productivity improves through a succession of parallel but random advances . . . Each advance often is limited by a shortcoming in another area (p20).

Nevertheless, despite the inevitable bottlenecks which will have to be surmounted in the development of adequate materials technology and components, none of the observers of automation suggest that any of these bottlenecks stand out as fundamental technological obstacles to the advance of full inter-sphere automation.

This would suggest that the re-emergence of the single sphere enterprise, characterisitc as we saw in Chapter 2 of pre-industrial revolution manufacturing activities, is a distinct possibility. Inevitably it will take time and will be subject to a variety of obstacles. Yet in principle, it remains a technologically feasible prospect save for the few strategic decision-making activities listed above and other specialized tasks such as design, sensing and repair. (Although even here automation possibilities are substantial: for example, many control systems are self-diagnosing, or incorporate redundant duplicating systems which are automatically brought into use when primary systems fail). But if the technological boundaries are relatively low, the diffusion of full inter-sphere automation may yet be limited by factors of an economic and social nature.

Economic impediments to full inter-sphere automation

Two linked factors are of relevance here. The first concerns the economic cost to supplying-firms and society at large of developing these automation technologies. These costs are partly 'human' in that they involve very substantial inputs of programming skills. For example, some of the computer-aided design equipment suppliers, although only covering a narrow range of the market, had by 1980 each already incorporated over 1,000 person years of software development (involving in excess of 7 million lines of programming) in their applications software.

But perhaps more significant is the second factor which reflects the ability of user firms to invest in radically new automation technologies. As we saw in Chapter 1, the emerging crisis of the pre-automated era was associated with the slower growth of markets and a decline in the rate of profit. So the financing of the installation of automation equipment will be problematic and it is in this context that the tendency of governments to finance the purchase of new information technology and the restructuring of established industries such as automobiles, steel, shipbuilding and basic chemicals should be seen.

A secondary phenomenom of importance here is the trade-off between automation and scale. As we saw, earlier rounds of intra-sphere automation were

largely limited to large-scale mass production sectors. And whilst the flexibility and low cost of electronics make it increasingly feasible to reduce the scale threshold at which intra-sphere and inter-sphere automation becomes economically viable in each plant (but not necessarily in each firm – see the following chapter), there will always be a tendency for the limited advantages conferred to very small-scale production batches to be outweighed by the costs which are involved in the development of these automation technologies. At the extreme it is highly unlikely that it will ever be worth gearing up a fully inter-sphere automated enterprise to produce a single product. And, here, there will inevitably be sectoral variations in which the greater the quality required, the shorter the desired lead-time and the higher the value of the final product, the more feasible will be the full automation of small batch production.

Social impediments to full inter-sphere automation

In theory automation has a great deal to offer society since it provides the potential to liberate us from the necessity to work whilst at the same time providing us with a high material standard of living. But the extent to which humans can be liberated from the tyranny of specialized work reflects not just the degree to which technology is able to relieve us from scarcity, but also the way in which society is organized. So the pace of diffusion of automation technologies will necessarily reflect the distribution of the benefits which their use confers. It was precisely this fear that the benefits of intra-activity automation would be distributed so unevenly which led the Luddite workers to destroy the new automated spinning technology in the early nineteenth century.

Having made this observation – which often leads to the too simplistic conclusion that because capitalism inherently distributes benefits less evenly than socialism, it will inevitably experience slower diffusion of new automation technologies – it is important to recognize the complexity of the historical and political factors which determine the diffusion of automation technologies. Thus, in observing the tendency of the Japanese to install systems-based inter-sphere automation technology more rapidly than their European (and especially British) and American counterparts, it is too easy to be led into explaining this by 'cultural' factors. More persuasive are analyses which situate the discussion of social attitudes to technical change in a wider, historically based context pointing, for example to the 'historic compromise' between capital and labour which has emerged in post-war Germany and in Japan, but not in Britain or Italy. In addition, the rapid expansion of markets has allowed some Japanese firms in the past to offer life-time employment, clearly making labour more sympathetic to the introduction of these technologies.

The point of this brief discussion is not to offer a determinate description and analysis of the social factors which will impede the spread of full, inter-sphere automation – for this will inevitably change over time and vary between systems – but to point to the fact that the diffusion of automation technologies must be seen in the context of a struggle. This struggle, as we pointed out in Chapter 1, is currently recurring between different types of capital and at the

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same time also between capital and labour: the degree and pace of diffusion will reflect this broader struggle for dominance and it is this subject which will be the central concern of Chapters 7, 8 and 9.

THE PROGRESS OF INTER-SPHERE AUTOMATION

Thus intra-activity automation technologies – most significantly those incorporating electronic control systems – are now widespread in each of the three spheres of production, and intra-sphere technologies are rapidly emerging as these individual electronics-based automation technologies are linked together. But what can be said with respect to the emergence of the final, full stage of automation in which automation technologies in different spheres are being linked together?

Hitherto, most literature on the subject of automation has been largely concerned with either the minute detail of individual intra-activity automation technologies, or with the overall, global impact of automation on society. However, emerging out of the production engineering literature is a set of views which although starting from a very different perspective – that is the primary orientation has been technological – has generated rather similar conclusions to our own. A recent study by Halevi (1982) draws together the state of the art of literature in this field and points to the likely picture of future technological developments.

Halevi is concerned with Hal-technology, derived from the Hebrew word 'Hal' which means 'all-embracing' and so characterized as:

> . . . a new, all-embracing computer-oriented technology . . . that views the manufacturing process as a single unique system (pviii).

The essence of Hal-technology is the development of inter-sphere automation (although Halevi obviously does not use this phrase) and flows from the recognition of the limited gains offered by intra-activity and intra-sphere automation. Thus, in relation to intra-activity automation, Halevi observes that:

> Development in the use of computers as an end to manufacturing have proceeded in a modular, disjointed fashion. Systems designed and developed to solve a specific problem as expediently as possible were necessarily limited in scope (p393).

This points to the need for intra-sphere automation. Here:

> The evidence shows that the economic benefits to be gained from integration [ie intra-sphere automation] far exceed those benefits directly attributable to individual development efforts [ie intra-activity automation]. This is particularly true in discrete part-batch manufacturing based industries because of such factors as the need to maintain both a flexible fabrication base and highly efficient controlled operation (p393).

However, Halevi observes that this intra-sphere automation has occurred in an unsystematic way, that is:

Integration of these systems [ie intra-sphere automation] has been attempted in some cases, but only as an afterthought. The resulting proliferation of disjointed computer systems tends to magnify manufacturing problems (p393).

All this points Halevi (and, he argues, production engineering in general) to the concept of Hal-technology, which we have termed inter-sphere automation. Thus:

Hal treats the manufacturing process as one interactive problem starting from engineering design to product shipment. It considers the manufacturing process as a nucleus of satellites rather than a chain of activities (pp393–4).

It is worth exploring the historical evolution of inter-sphere automation – as seen through Halevi's production-engineering eye – in greater detail. Halevi points to four stages in the developing use of computers in production, the logical outcome of which will be the development of inter-sphere automation in which the various activities in different spheres will not just be linked together in an ad hoc manner but will be systematically incorporated as sub-elements in a comprehensively organized system.

The first of these stages was the *application approach* 'to solve a specific problem, or to supply specific information to a specific department or person' (p7). These technologies were isolated ('stand-alone' in the jargon), but their superiority over existing technologies led to the rapid spread of computers in industry. However, it soon became apparent to management that the 'data required for manufacturing or by top management are usually a combination of data from several stand-alone applications' (p8) so leading to the second phase of *data entry integration*. In this stage, the embryonic form of intra-sphere automation, information came to be stored in a centralized, computerized data base. Although this provided economies, it increasingly led to problems in the control of updating information (given varied users), the non-overlapping nature of data (not all users required the same data) and a consequent degradation in the quality and ease of access to information. Perhaps more importantly in these mainframe-computer based systems information tended to be application-oriented rather than systems-oriented and this placed obstacles on the development of intra-sphere automation. Consequently, as from the middle of the 1970s, intra-sphere automation was built around *distributed processing*, the third of these phases. These interactive, minicomputer-based systems (as we saw in the case of CAD in Chapter 3) allowed for low-level intra-sphere automation and spread rapidly. (One US Corporation cited by Halevi had 35 small computers in 1975, 102 in 1976 and 150 by mid 1977). The problem with these distributed systems was that they were too narrowly intra-sphere in approach to satisfy upper management's desires to spread wider forms of automation. Although they were able to eliminate duplication and inconsistencies and to make information available to other users (usually in the same sphere) they were too particularistic to allow for the wider ultimate benefits of inter-sphere automation.

All this pointed Halevi to the need for an approach which would make inter-sphere automation possible. He argues that the individual sets of this all-

embracing technology are already in existence and the task now lies in putting them together. However, he does make the very important proviso that for this to succeed it is crucially important that inter-sphere automation should not proceed in a narrow framework in which individual activities in different spheres are linked together in a half-hearted, piecemeal fashion. It is vitally important to recognize that production is a unified system with its own respective subsets rather than a conglomeration of related, but separate systems.

SOME EXAMPLES OF INTER-SPHERE AUTOMATION

It is important to recognize that inter-sphere automation is not a phenomenon of the future, but is increasingly one of the present. To illustrate this it is useful to point to a few examples to show that the gains are already being realized: these are drawn from an analysis of firms using computer-aided design (CAD) technology (Kaplinsky, 1982b).

In Chapter 3 we examined the development and diffusion of automation technologies in the sphere of design, notably with respect to interactive computer-aided design technologies. We also considered some evidence on the gains realized from intra-activity and intra-sphere automation obtained from a variety of American and British firms which had made use of the new design automation technology. However, a number of these firms were beginning to widen their horizons and to reap the benefits of inter-sphere automation. Indeed the substantial number of these utilizing firms were at pains to point out that as far as they were concerned, the major benefits from use were going to be felt in downstream activities in the two other spheres of production. Assessing the state of the art of these downstream benefits poses substantial difficulties, partly because of the difficulties in estimating the extent of these links, partly because they are gradual and emerging, and partly because of the very substantial variation in the nature of the potential links, which depend upon the sector, the product and the type of factory organization. Therefore, it is only possible to illustrate the types of inter-sphere links between CAD and activities in other spheres as an example of the sorts of competitive advantages which can arise from the introduction of inter-sphere automation technologies. For obvious reasons related to the earlier discussion in Chapters 4 and 5, we can distinguish between benefits related to information coordination and benefits related to manufacture.

Information coordination

The extent of information required by most firms which utilize CAD are generally beyond the processing capabilities of minicomputers, and consequently in the case of most user-firms, parts listings, bills of materials and ordering were organized around mainframe computers, separated from the CAD systems. While it is quite possible for these different computers to intercom-

municate directly, as a general rule there is some form of human interface between the two systems as well as some form of duplication of data generation and processing. However, the more powerful mainframe computers have no such difficulty and in fact this integration of data processing and analyses is the specific philosophy of IBM CAD-system marketing as embodied in their COPICS (communications-oriented-production-information-and-control-system) systems (Halevi, 1980). Moreover, as the turnkey CAD vendors move to the more powerful 32-bit computers (which they are all currently doing), their ability to integrate CAD-analysis software and batch-information processing will increase. Thus the unification of the CAD database with these in the coordination sphere is an increasingly common phenomenon.

Once this is done, the degree to which firms will be able to reap substantial economies will depend upon their existing structuring of information. For example, one of the users (which designs and builds process plant) has already made substantial inroads into parts listing via their mainframe computer: as a consequence of having a more specific knowledge of their needs for parts, on-site contingency costs have fallen from 15 per cent to 5 per cent since they were able to keep a much smaller supply of components, and construction was less frequently held up by a shortage of crucial components. In other cases, the pre-CAD organization of information had been suboptimal and the installation of CAD systems in these enterprises had forced the downstream systematization of inventories. This led to a more structured organization of warehousing and parts coding. More importantly, it led to a reduction in the number of different parts held, as the systematization illustrated unnecessary proliferation of part-types. In particular it had given an impetus to the development of the 'group technology concepts' which we will discuss later in this chapter.

Downstream information flows need not be confined within enterprises, of course. A particularly pointed example emerges from the British motor component industry where a British automobile firm is building a new car under licence from a Japanese firm, and to its design. One of the major UK component suppliers complained that the specifications supplied by the Japanese firm for a particular part were unintelligible: 'instead of sending us a drawing, all we got was a digital readout'!

Manufacture

There are very many potential links between design and manufacture and the specific benefits available depend upon the nature of the process and products involved. We illustrate some of these to give a flavour of some of the potential benefits which arise.

Machine setting: the control mechanisms of numerically controlled machine tools utilize the same basic digital information as the CAD systems (although for this information to be utilized it has to pass through a post-processor which, in the absence of direct numerical control (DNC), prepares the paper tape for the computer-numerical-control (CNC) machine tools). Consequently it is not a complicated task to link the two systems. In most cases, CAD users have

drawn links between CAD designs and numerically controlled milling and cutting machines; but in one firm (which is a sign of a future trend) specifications for the automatic testing equipment were fed directly from the CAD system and in another active plans were being made to link assembly equipment to the CAD system. The benefit of these links are manifold, including the displacement of machine operators and a reduction in errors in machine setting.

Production planning: once a unified (and accurate) database has been established in the CAD system it is possible for this information to be assessed by multiple users. This not only spreads information more widely through the plant but also many firms found that it speeded up the release of final drawings (in one case from three weeks to less than eight hours) and allows for a single, corrected master-design to be utilized, rather than the previously haphazard proliferation of incomplete drawings.

Materials saving: a particularly important benefit of CAD is a saving in materials due to the optimization of design and nesting (the name given to the programs developed to cut shapes out of a sheet of material). In one firm optimized designs had reduced the number of parts in a machine by 50 per cent; in another, CAD had made it possible to reduce silver utilization by 50 per cent in a process in which silver comprised 30 per cent of direct production costs. Benefits from CAD nesting programs are widely felt: one sheet-metal user had reduced wastage from 40 per cent to 26 per cent in its first-generation nesting program; its annual savings in sheet metal equalled the total annual wage bill.

Prototypes: four users concluded that as a primary benefit, more accurate CAD drawings reduced the need for and costs of manufacturing prototypes. In one particularly graphic case, an electronic instrument had been built for an aircraft (at a cost of $100,000) which did not fit into the space available in the cockpit; this required a complete redesign which the firm argued would not have been required had a CAD system been utilized in the first place.

Extra-firm benefits: a major and rapidly expanding field for CAD systems is 'piping' software which is used for 'interference checks' (ie whether pipes obstruct each other or other sets of equipment in a process plant). Despite the fact that by 1981 none of the existing turnkey CAD suppliers yet appeared to have had a fully mature 3D software package for this, (although all had them under active development) the benefits in construction were already being felt. In the past, a significant but unquantified cost in the construction of process plant was incurred in the on-site rectification of design errors which resulted in interferences. The elimination of such design errors is already beginning to have an impact in reducing construction costs, despite the immaturity of much of the available software.

Another example of a trend towards inter-sphere automation can be drawn from the recent re-equipment of a locomotive-building plant by General Electric in Erie, Pennsylvania. Faced with the potential revitalization of the US railroad system and the recent success of Japanese and European firms in supplying metropolitan transport systems with new equipment, GE is investing $316m in a new automated plant.

Starting at the beginning, the design output of the engineering department will be passed on to the manufacturing engineers in electronic form, rather than as drawings, and will then move through materials control, which will automatically schedule and order materials and keep track of stock and production flows.

All this information will come together in the factory in the host computer, which will contain in its memory details about how, when and what to produce. This in turn will send instructions to the computer-controlled equipment, such as numerically controlled machines and robots, which will actually do the job. Quality controls, financial data, and customer service records will also be plugged into the same system (Lambert, 1983).

It is significant that GE expect such substantial savings – 25 per cent in direct labour, 20 per cent in material costs, 20 per cent reduction in inventories – that it expects the investment to be self-financing through savings in working capital alone. Already the introduction of a flexible manufacturing system (ie intra-sphere automation) to produce a family of motor frames and gearboxes typically completes job-lots in sixteen hours with four people working, compared to the earlier system which employed seventy people on twenty-nine different machines and took sixteen days. As a 'bonus', parts quality is higher and floor-space is cut by 25 per cent.

FACTORS AFFECTING THE SPEED AT WHICH INTER-SPHERE AUTOMATION DIFFUSES

In earlier sections of this chapter we have considered whether full inter-sphere automation was possible and on balance decided that this was so. We have also given some examples as a flavour of the sorts of benefits to be realized from inter-sphere automation. However, it is important to be aware of the difficulties which might arise in the development of inter-sphere automation over the coming decade. In addition to the social and economic obstacles to full automation discussed earlier in this chapter, two more specific factors are relevent. These are the difficulties in capitalizing on systems-gains given the tendency towards creeping incrementalism and the difficulty in harmonizing and matching information generated in disparate spheres.

Incrementalism: the hidden dangers

Since automation technologies are still evolving and are generally optimized on the basis of experience, their evolution will of necessity be incremental, although nevertheless occurring at a rapid pace. Additionally not only are the technologies evolving but so too are organizational structures within which they are implemented. There is a great danger in this evolution that the same fate will beset inter-sphere automation as that which befell, according to Halevi, its intra-sphere predecessor, leading to suboptimally organized subsets of technological linkages which are unable to capture the full extent of potential

systems-gains. In the end, as Halevi points out, efficency considerations will force enterprises to take a holistic view of the production process, but the path to this destination may be tortuous unless this global perspective is recognized from the outset. This recognition appears to exist in Japan; it also has penetrated individual American firms such as General Electric, IBM and Westinghouse who, as we have seen, have recently come to grasp the potential magnitude of the new electronics-based automation technologies. Thus, rather than adapting an existing plant, General Electric preferred to construct an entirely new and highly automated factory for the manufacture of washing machines. Attention is therefore drawn to the importance of seeing production as a system. The capturing of these systems gains is a decision to be exercised at the highest levels of strategic management (see Chapter 5). This involves two separate phases. The first is the *recognition* of the potential benefits to be derived from inter-sphere automation and of the dangers in trying to achieve these benefits via piecemeal adaptations to existing production systems. Halevi describes the necessary involvement of management on the following terms:

> for this stage to be successful, it must be understood that system integration is not a data processing slogan or technique. It is, above all, a management technique in which it is realized that the manufacturing process is neither a set of independent systems nor several sets of integrated systems, but one logical, overall system . . . without management involvement, the chances are next to zero (p12).

The second phase is the *power* which management has, as the representative of capital, to enforce the required changes in production technology and methods. For as we have seen (and will discuss further in Chapter 8) inter-sphere automation requires very different work practices and almost always involves much lower levels of labour. In most circumstances, particularly in the UK, Italy and France, these changes will be resisted by the workforce, many of whom will be affected in an adverse way. Thus it is an open question whether, even if management recognizes the need for changes in the production system, it will be able to carry through the necessary measures in an adequate way, or in the approriate time scale required to cope with the advances made by competitors.

Harmonizing information

As we have seen the history of electronics in production has been characterized by the gradual introduction of a variety of individual intra-activity automation technologies, each with its own data needs, data entry systems and databases. Whatever the capabilities of the physical hardware to link these various databases together (through, for example, the introduction of local area network systems (LANS) which mate together the digital output from a variety of separate electronics systems), unless the information exists in a format which allows it to be used intelligibly, the full gains will not be realized. For example, if a component coding system used in the warehouse is different to that used in design or production control activities, the potential gains from inter-sphere

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cannot be realized. Once again this requires a recognition by management that production is a fully integrated process made up of individual, harmonized subsets, rather than a series of separate if vaguely linked activities.

Associated with this is the rationalization of design and process to limit the number and types of components, hence allowing this harmonization of information bases to proceed in a productive manner. The central concept here is that of group technology (GT) which was initially developed in the USSR and Germany in the 1950s, and subsequently sank into obscurity until the emergence of intra-sphere and inter-sphere automation technologies in the late 1970s. Although there are a variety of different definitions of this concept the central idea is that enunciated by Salaja:

> Group-Technology is the realization that many problems are similar and that, by grouping together similar problems, a single solution can be found to a set of problems, thus saving time and effort (quoted in Halevi, p77).

Two examples may be given of group technology and the potential gains it offers. The first is that arising in design where the recognition that there exist 'families-of-parts' has allowed firms to reorganize designs into a more modular form taking advantage of basic component designs. In the pre-CAD days when designs were all manually done, it was not necessary to utilize 'families-of-parts' methodologies, but the capability of CAD to store basic designs and to scale them up or down automatically has vastly increased the potential benefits to be gained from this form of group technology. A second example is that arising from workcells: Halevi cites studies which estimate that using conventional technologies only around 5 per cent of production involves direct working; of this only 30 per cent involves machining and 70 per cent is taken up with positioning and tool-changing. Thus only around 1½ per cent of total manufacturing time is taken up by actual machining. Workcell concepts are thus being developed to change this rate by grouping together similar types of process and parts and to consequently reduce the non-machining component in production. Group technology is still in an embryonic form; moreover it will probably never be possible to entirely automate this classification system (Halevi, p55). But, nevertheless, the systematization of information regarding design and process, and its links to automation technologies, is undoubtably an important factor influencing both the time scale and the extent to which the benefits of inter-sphere automation will be realized.

A TIME SCALE FOR INTER-SPHERE AUTOMATION

Given the various sets of impediments discussed above it is not easy to determine the time scale within which inter-sphere automation will emerge. In particular, as we have pointed out, these obstacles probably have more to do with political and social factors (such as the relative power of labour and capital, particularly in the context of individual countries) than technological ones, and

are hence difficult to predict. However, a number of observations can be made. First, we have already begun to see examples of inter-sphere automation and these technological link-ups are occurring at an extremely rapid pace. Second, many of these new technologies are being innovated in an incremental manner and, despite the emergence of automation-facilitating technologies such as local area networks, this piecemeal approach may well hinder the pace at which full inter-sphere automation will proceed. Third, many of the more popularly celebrated examples of the automated factory (such as the Fujitsu Fanuc factory in Japan which employs 100 people on the day shift and only one at night) are really exercises in intra-sphere automation, largely confined to the manufacturing sphere. And fourth, it is in the less glamorous context of CAD that the first real signs of inter-sphere automation are beginning to emerge.

We are therefore faced with a picture of incremental technological change. But we should not confuse this incremental, piecemeal approach with the pace at which it proceeds and here the signs are that the speed of diffusion of inter-sphere automation is rapid. Once the coordination sphere sees widespread intra-sphere automation (a phenomenon which is likely to occur within the 1980s) then we can anticipate the emergence of full inter-sphere automation, the true 'factory of the future'. In summary therefore the 1980s are likely to see increasing signs of individual sets of inter-sphere automation technologies and by the 1990s we will surely see the fairly widespread emergence of fully automated production in many sectors including those now characterized by small batch production.

Lest this be seen as fanciful or insufficiently cautious it is instructive to review the progress of intra-sphere automation in the manufacturing sphere since Bright (1958) wrote his classic study in the mid 1950s. As we saw in Chapter 2 Bright foresaw 17 different levels of mechanization (see Figure 2.3); however, in the 13 advanced plants which he monitored, mechanization seldom exceeded level 6. In 1958 Bright had this to say of the prospects of mechanizing the emaining levels:

> It should not be inferred that all operations will therefore continue to rise and eventually reach the 17th level (Anticipatory Control) or something close to it. Quite the contrary – although there is a strong economic spur to raise activities off level 1, 2, and 3 (even 4), there appears to be an equally strong economic rein after reaching levels 5 and 6. In many cases there literally is neither necessity nor economic advantage in achieving mechanization above, say, level 6, with an occasional use of levels 8, 9 and 10 where needed (p223).

Now Bright was observing a world which was largely in the pre-electronic era; in the absence of the flexibility which electronics allows (as in the flexible manufacturing systems discussed in Chapter 4) Bright was probably correct to anticipate obstacles to more extended mechanization. But the introduction of electronics has changed all this and, barely twenty-five years after, Bright made these observations:

> Todays advanced CNC machine tools and 2nd generation robots achieve approximately level 16 in Bright's classification (Husband, 1982 p2).

Similarly when referring to Amber and Amber's ten orders of automation (Figure 2.2), which are more ambitious then Bright's levels of mechanization, Husband observes that

> Todays 1st and 2nd generation robots start to meet A6 [ie Order 6] characteristics (passim).

With the benefit of hindsight, therefore, it is wise not to underestimate the extent of possible inter-sphere automation. Moreover, given the effect of the growing crisis in the world economy on competition between firms, and their technological response to this competition (see Chapter 1), it would similarly be foolish to underestimate the pace at which this automation will proceed.

4

INFORMATION TECHNOLOGIES, THE SERVICE SECTOR AND THE RESTRUCTURING OF CONSUMPTION

P. BLACKBURN, R. COOMBS & K. GREEN

P. Blackburn, R. Coombs & K. Green, *Technology, Economic Growth and the Labour Process*, Macmillan, Basingstoke, 1985, pp. 146–92.

INTRODUCTION

As we first outlined in Chapter 2, information technologies are applicable not only to such manufacturing sectors as small-batch engineering but also to other sectors which have traditionally proved very difficult to organise on Fordist lines. In particular, this includes those sectors which have not been based on the use of much sophisticated machinery, either in terms of transformation, transfer or control. We refer to the application of information technologies in the supply and production of so-called 'services' to which this chapter is devoted. The chapter examines this sector to see whether neo-Fordist developments can be identified. After looking at what the service sector actually comprises, we examine various organisational changes that have taken place in one part of the sector that has been most affected by developments in computer technology since the 1950s – clerical work. We wish to develop the idea that information technologies being introduced into such work in the 1980s are best seen as associated with neo-Fordist organisational changes.

We will also seek to demonstrate that the concept of neo-Fordism cannot be confined merely to describing some transition *within* existing service industries or occupational sectors. Indeed the promise of information technologies, their recasting of traditionally labour-intensive activities of information handling, implies a substantial reorganisation of the existing service industries themselves, as the

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patterns of service consumption amongst the population alters. Just as Fordism for its extension to a large number of industries, required a reorganisation of the consumption patterns of the majority of the population so, we would argue, might neo-Fordism, though not necessarily of the same kind nor on the same scale. In other words, for a successful capitalist exploitation of information technologies, fairly substantial changes may be required in the way people in developed capitalist countries satisfy their needs. In the second half of this chapter we discuss this restructuring of consumption using possible changes in the ways in which health care is provided as an example.

THE SERVICE SECTOR

The service industries provide many of the prerequisites for the functioning and growth of capitalist economies. Many are concerned with the distribution of goods and raw materials, the circulation of capital, the production and reproduction of labour power and the provision of information and expertise. Many of these service industries are particularly labour-intensive and in all developed countries a large proportion of services are provided by the state rather than by private capital. Much of the non-state-financed service industries consist to a large extent of small capital and the self-employed. In contrast to manufacturing industries, few of the service industries have significant transnational capital, although this is beginning to change.

As the current economic crisis has continued, reductions in state expenditure on service industries along with the search – especially amongst equipment manufacturers – for new markets, has made the service industries very attractive targets for capitalisation. Similarly, the current contraction of the private manufacturing sector in many countries has forced service contractors to look to the state sector for growth especially in such areas as catering, cleaning and security.

The services do not clearly exist as a sector; they are a heterogeneous collection of industries. The main thing they have in common is that their 'products' are not in the main physical goods but are in some way intangible, impermanent and immaterial. A lot of ink has been spilt in attempting some embracing definition of what constitutes the service sector, much of it wasted by trying to bring unity to what is better left as diversity.[1] Gershuny and Miles (1983)

have pointed out that the definitions are of limited value since the term 'services' has at least four meanings.

There are certainly *service industries* which provide the immaterial service products as well as physical products which have been transformed by such service activity. Such industries include the familiar, and sometimes overlapping, categories of tertiary industries (transport, communications, utilities), personal services (hairdressers, dentists, catering etc.), goods services (maintenance of cars, consumer goods and buildings, etc.), producer services (finance, banking, legal and research work), cultural industries (publishing, broadcasting, advertising, etc.) and public services (education, health and public administration). But many of the *service products* of these industries are also produced by manufacturing industries who offer them for sale (for example, computer manufacturers who offer maintenance services) or who consume them internally to their own organisation (for example, some firms have their own transport departments). So, *service workers*, people who actually produce the service products, are distributed across all industries, 'service' and manufacturing. In addition, it is necessary to identify *service functions*, necessary human requirements, or 'needs', which can be satisfied in a number of historically specific and changing ways. (For example, the human need to move from place to place can be satisfied by the transport *service industry* of buses and trains or by the self-drive physical products of the automobile manufacturing industry).

Exactly how the changing mode of satisfaction of various human service functions is linked to changes in the structure of service industries and employment is an important question. We will return to it later in considering the applications of information technologies. For the moment, let us note that Gershuny and Miles divide services into a number of categories thus:

1. MARKETED SERVICES – namely service products which are provided in advanced capitalist countries predominantly by private capital via competitive markets. These include:
   (a) **Producer services** – provided in the main to and for the capitalist- and state-production sectors rather than to individual consumers; namely:
   Finance – banking, credit, insurance, real estate, etc.
   Professional – legal, research, advertising, etc.
   Other business – cleaning, security, maintenance, etc.

(b) **Distributive services** provided to and for capital- and state-organisations for the transfer and storage of people, goods and information of all kinds; namely:
Transport, storage – the physical movement and storage of goods and people by road, rail, air and water
Communications – the physical and electronic transfer of letters, speech, financial and other data by postal, telephone and computerised services
Wholesale and retail trades – that is, the sale and trading of manufactured goods and of personal services

(c) **Personal services** – the provision of services direct to households or individuals or to households and individuals' possessions; namely:
Domestic – the performance of domestic activities such as cleaning, laundry, personal care (for example, hairdressing)
Lodging and catering – the provision of hotels and restaurant services
Repairs – the servicing of household durables and of domestic buildings
Entertainment and recreation – the provision of sports, arts, and general leisure/cultural services outside and, by cable, etc., inside the household

2. NON-MARKETED SERVICES – namely service products which tend to be provided by state-owned, state-financed and/or state-administered organisations in advanced capitalist countries; namely:
Health care – the services of doctors, other hospital workers, dentists, etc. within 'health services'
Education – education and training services offered by nurseries, schools, and higher and further educational institutes
Other welfare – personal social services (for example, social work), surveillance (policing) and other general government services (for example, public administration, communal cleaning).

We cannot go into the likely significance of innovations in information technology in all these service activities. Table 7.1 presents a summary of some of the most probable developments.

The concern of many writers to chart and quantify the growth of the services over the post-war period reflects their view that developed countries are moving to a 'post-manufacturing' or, less precisely, 'post-industrial' phase of development. In this phase, it is

TABLE 7.1 *New technologies and process and organisational innovations in services*

MARKETED SERVICES

PRODUCER SERVICES

Finance

Process Innovations: Electronic data processing for inter- and intra-organisation transfers; automatic dispensers and tellers; point of sale terminals; office automation on a large scale; use of terminals by agents in insurance and real estate, speeding up transactions.
Organisational Innovations: Specialised consultancy and accountancy services brokerage between different service institutions; movement of financial organisations into providing infrastructure for trade, small businesses and retail.

Professional

Process Innovations: Computer-aided design and routinisation of production of documentation with office automation; retrieval of data from extensive bases; some development of home-based office.
Organisational Innovations: Self-help and citizens' advice for legal and related services to private individuals extended with 'telematics'.

Other Business

Process Innovations: Telecommunications used to improve scheduling of tasks; greater use of automated security equipment, fast food and vending equipment.
Organisational Innovations: Contracting out of businesses' 'peripheral' tasks; increase in 'voluntary' (i.e. unpaid) work.

DISTRIBUTIVE SERVICES

Transport/Storage

Process Innovations: Automation of stock handling and accounting; more containerisation of transported goods; increased efficiency of rail transport with more rapid trains and improved routeing; use of telecommunications to improve booking, ticket sales automation, etc.
Organisational Innovations: In goods transport, private road transport services displacing rail; in passenger transport continued reliance on private motor-car with some increase in 'community transport' services; development of local goods delivery centres for final consumers in urban areas.

Communications

Process Innovations: Electronic handling of routine letters and packages; development of electronic mail, high capacity optical cables, more highly

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automatic telephone systems, communicating computers and word processors, access to data banks, videotext.
Organisational Innovations: New information services, complementing expansion of information and entertainment services for households; growth of community presses (and other media?) as 'alternative' information sources?

Wholesale/Retail

Process Innovations: Automated stocktaking, tied in retail sector to point of sales equipment and potentially linked directly to financial and wholesale institutions; growth of mail order complemented by 'teleshopping'; increased size of retail and wholesale units with more self-service.
Organisational Innovations: Delivery services tied to teleshopping; increased electronic consumer information systems; increased use of freezers and other domestic storage equipment with self-production expanding consumption of garden and household tools.

PERSONAL SERVICES

Domestic

Process Innovations: Increased productivity with economies of scale and specialisation in laundry and similar household services.
Organisational Innovations: Improved domestic technology – vacuum cleaners, washing machines, etc. – facilitates shift toward informal production of domestic services; flexible working hours plus women's movement pressure alters domestic sexual division of labour? Some professional services (such as computer software, interior design) offered direct to households via advanced telecommunications systems/home computers.

Lodging/Catering

Process Innovations: Improved reservation and booking services in hotel services; growth of 'fast food' outlets with off-site prepared food and microwave ovens, etc.
Organisational Innovations: Changing household patterns stimulates more 'eating out'; growing home use of pre-cooked, convenience foods.

Repairs

Process Innovations: Use of automatic diagnostic equipment spreading from car repair and household appliance maintenance; simplification of maintenance through use of microelectronic components.
Organisational Innovations: More do-it-yourself repairs subject to degree of 'penetrability' of electronic equipment.

Entertainment/Recreation

Process Innovations: More use of telecommunications in booking and sales; more 'hi-tech' entertainments.

Organisational Innovations: Growth of cable TV, video recorders displacing 'live' cinema and theatre further; extension of local TV and radio transmissions.

NON-MARKETED SERVICES

Health

Process Innovations: Computerisation of records and office automation; more efficient catering services; electronic diagnostic and monitoring equipment; new prosthetics technology; new ranges of pharmaceutical products.
Organisational Innovations: New drugs and biological diagnostic methods for various medical conditions; preventive and simple diagnostic services possibly made easier to use with information technologies; growth of paramedical and advice services; wide use of automatic diagnosis and screening in health services?

Education

Process Innovations: Distance learning systems enhanced through telecommunications, video and computer equipment; use of computers in 2° and 3° education.
Organisational Innovations: New educational packages for community education and for disadvantaged groups; educational packages combined with entertainment for home use.

Welfare

Process Innovations: Computerisation of records; automation of advice services and administration.
Organisational Innovations: Development of self-help groups producing community services and seeking improved services from state; blurring of policing/community work/surveillance roles in state agencies?

SOURCE *Adapted from Gershuny and Miles* (1983)

said, the dominance of manufacturing employment becomes more and more eclipsed by the growth of the service sector as the major source of employment. This is seen historically to mirror the decline of employment in primary industries of agriculture and extraction. However, the post-industrial thesis of the early and mid-1970s has been challenged by events in more recent times. The idea that manufacturing would become almost completely mechanised, leaving labour-intensive work in the service industries or (if much less so) in the service occupations of manufacturing, to take up the slack, assumed a low level of labour-saving technological change in services.

(This low level may have been due to the sheer technical difficulty of mechanising service tasks, the low pay of most service workers or the deliberate job-creating policies of inverventionist governments in the public sector.) It is clear now that this is not in fact likely to be the case, both because new technological developments can indeed mechanise many service tasks and because the prevailing economic and political situation discourages an extension of public, labour-absorbing services.

Yet while the optimistic social commentators of post-industrialism were replacing their vision of the 'service society' by a rather similar notion of an *information society* (this being a society where information is the dominant commodity being traded rather than manufactured goods)[2] other, pessimistic commentators foresaw the effects of information technology in services leading to a major shake-out of service workers in the so-called white-collar jobs (Jenkins and Sherman, 1979; Hines and Searle, 1979). The common thrust of these arguments was that there was likely to be a large degree of surplus labour – engaging either in 'leisure' or unemployment – depending on such matters as the policies of both the state and individual firms on job-sharing and, more vaguely, changing attitudes to the presumed 'work ethic'. The rising numbers of unemployed in developed societies from the late 1970s seemed to indicate confirmation of these trends.

Although few people would argue now that the high level of unemployment in the advanced capitalist countries is a direct result of the introduction of new technology in manufacturing and services, the present orthodoxy is that any upturn in the economy would result in jobless growth certainly in manufacturing and, most probably, in many services. While much of this writing has been the stimulus to debates on the effects of new technology, few commentators have been sensitive to the constraints of political economy, the barriers to increased mechanisation especially in the services, or the emerging patterns of technological and organisational change both within and between sectors.

Of course there are enormous difficulties in discerning technological and social trends at the level of the service sector as a whole just as it is difficult to talk about general trends in manufacturing as a whole rather than in specific industries. Yet as soon as we move from the aggregate to the level of particular industries and types of service, the multiple dynamics of service industries become easier to see. Recent work (Robertson *et al.*, 1982; Gershuny, 1983; Gershuny and Miles,

1983) has examined the main locations of growth in service industries. Over the post-war period around two-thirds of service industry growth is accounted for by the growth of state services, especially administration, education, welfare and, except in the case of the USA where it is mostly privately run, medicine. Most of the other one-third of post-war growth is accounted for by the expansion of producer services. This expansion is, in part, a reflection of the increasingly complex social division of labour in the production of goods and of the increasing importance of non-direct, conceptual tasks in contemporary manufacturing. (From 1924 to 1975, the proportion of administrative, technical and clerical workers in British manufacturing industry went up from just over 10 per cent to about 28 per cent; see Crum and Gudgen, 1978.) In aggregate terms there has been a relatively stable or slightly declining level of employment in the marketed services in developed capitalist societies. Especially in the cases of entertainment, transport and domestic services, growth in consumption in these areas to satisfy these service functions has been achieved through the purchase of goods like cars, television and domestic appliances.

As we have said, another way of characterising this service work is in terms of occupational categories. This has the advantage of capturing service work which does not take place in service industries as such. By defining service industries as concerned with the production of intangible products, as distinct from manufacturing production, such a definition neglects the dependence of a sizeable part of manufacturing activity on a variety of indirect servicing tasks, often, but not always, taking place in offices. These are an essential component of the production of the physical product: in Chapter 6, in the case of small-batch engineering, we described the work of design, planning, stock control, cost-accounting and progress-chasing which are non-direct production activities but are nevertheless essential to overall production. Increasing in importance are other white-collar functions within the manufacturing sector: marketing, research and development (R & D), purchasing, distribution, corporate finance and administration. This is in addition to indirect services such as plant and building maintenance, catering and cleaning. In this sense, a more adequate coverage of services is gleaned from service occupations rather than service industries despite the current trend for many services to be hived off or subcontracted from service firms.

In the rest of this chapter then we seek to focus on some specific

service industries and occupations to illustrate some of the developments within which information technologies might be implicated.

CLERICAL INDUSTRIES

Information Technologies in the Office

Office machinery and computers, along with the telecommunications systems and associated software needed to operate these elements and link them together, collectively known as 'information technology' (IT), are certainly of great applicability to all service sectors. Indeed for many, IT will turn those services from highly labour-intensive, paper-shifting, minimal technology activities into fully-fledged tertiary mechanised industries, with massive leaps in labour productivity in a comparatively short period of time – hence the analogies which some writers draw with the Industrial Revolution which involved similar leaps for some manufacturing industries, cotton spinning in particular.

Consider, for example, the simple process of composing, typing and sending off a letter, say from some headquarter order department to a customer in response to an enquiry. Envisaged as a sequential process, the activity can be portrayed as in Figure 7.1.

The squares represent transformation processes in which, by hand and brain, words are conveyed to paper either for the first time or in correction. The various paper drafts are transferred, between author and typist and clerical assistant, entirely by hand up to the postal stage where their transfer to the recipient may be accomplished by mechanical means, either in sorting or in transport. Until recently, the technological component of these clerical labour processes was limited to dictaphones, typewriters, franking machines, post office sorting machines and motor and rail vehicles. Electronic office machinery and advanced telecommunications makes it possible (although over what timescale is disputed) to eliminate many of these steps in transformation and in transfer, as well as in some aspects of the control of transformation (for example, layout, pagination) embodied in the actions of skilled typists, by 'electronicising' the entire process after the initial data entry involved in typing. With automatic voice transcription devices, it has been suggested, there can be further reduction as even the necessity for typing is removed.[3]

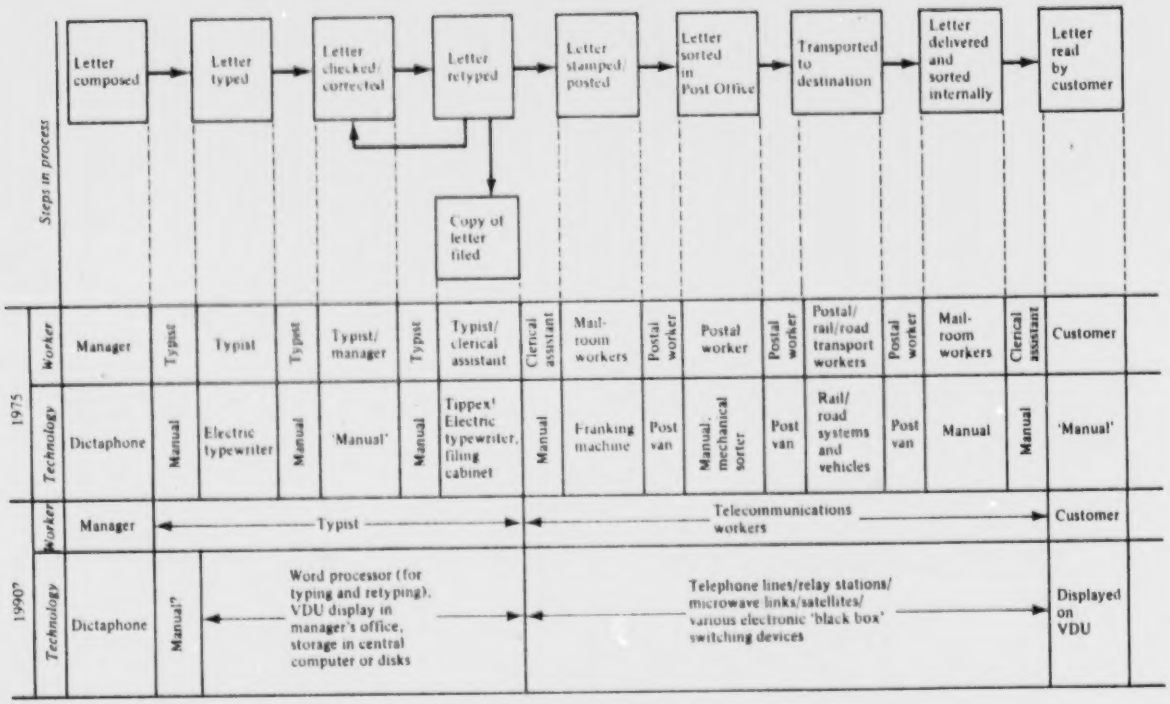

FIGURE 7.1 *The clerical labour process and new technologies*

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The manipulation of the text of the letter, its permanent storage and its transfer to the customer become highly mechanised in all three dimensions with few places left for any need of human intervention after the initial composing and data entry actions.

Although such equipment is being installed at a brisk pace in the offices of some companies, the rate of diffusion must not be exaggerated. Office equipment manufacturers, as might be expected, forecast that fully integrated systems – the so-called electronic office – will rapidly diffuse into the larger offices over the next five years; but, as we pointed out in Chapter 2, the speed of diffusion depends on many factors, most particularly the presence of an adequate advanced telecommunications infrastructure to handle what would be a huge increase in the electronic transmission of words, data and graphics. Such infrastructures are being installed on a world-wide level and they make up the technological core of current political disputes over European state telecommunications authorities which are being dismembered in order to clear the way for international corporations to take over the long-distance national and international trunk lines. In contrast to the local telecommunications infrastructure these are very profitable and are especially used by large, often transnational, business users for corporate communication and data flows. The enormous problems of infrastructural provision (such as, who pays for cable TV? how can privacy be protected?) and equipment incompatibility beween systems of rival producers means that the arrival of the electronic office is not as imminent as the manufacturers would have us believe. A further problem arises from the advantages of cost, durability and portability which paper has over electronic communications equipment, as well as its being the already existing medium. The information technology 'poor' will use paper for a long time to come, hence it will be a rare office that turns out to be 'paperless'. In addition, even if some parts of the clerical production process are mechanised, the initial *preparation* of documents in the creative act of composition will still be a highly skilled, professional 'craft'.

Many commentators have seen the introduction of computerised office machinery – particularly the electronic word-processor – as the latest and most substantial extension of a long process of introducing Fordism into office work. In the rest of this section we examine this view. We shall argue that straightforward Fordist reorganisation of clerical work around information technologies will be confined (as it has been in the past) to those types of clerical work

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where standardisation of the clerical product is easiest. For clerical activities of high variety however – and it is these which have the lowest labour productivity – information-handling devices like word processors and telecommunication networks, although permitting some standardisation and reorganisation of work structures, are more limited in their effects and in this respect must be examined in different terms. As with our analysis of small-batch engineering developments we prefer to see the differences as constituting a different form of production process, namely neo-Fordism. As defined in Chapter 5, neo-Fordism is intended to describe processes displaying technological developments in control mechanisation which permit high variety in their transformative capacity, organisational changes which favour less hierarchical work-roles and an informational infrastructure which can integrate different sub-units of the production process to permit various forms of decentralisation. The information technologies that can be employed in offices favour such informational infrastructures since they permit the rapid on-line manipulation of all sorts of data.

Fordism in Office Work

(This section and the one immediately following draw extensively on Softley, 1984.) Offices of varying sizes are found in all branches of production but it has been in service industries with large amounts of clerical work, indeed where the service *is* the processing of all forms of paper (orders/receipts/money) where the most successful attempts to emulate Fordist forms of manufacturing organisation have taken place. The best examples of this are banking, insurance and mail-order administration. In his discussion of the history of office work, Braverman describes its reorganisation over the last sixty years as leading to the creation of: 'A stream of paper . . . which is processed in a continuous flow like that of the cannery, by workers organised in much the same way' (1974, p. 301). Strassman (1982) refers to this as the 'classical organisational structure' in which 'standardised management, using standard operations concepts, imposes standard operating procedures on its employees' to satisfy customers with 'standard tastes and standard purchasing habits'.

Such standardisation has been underway since the turn of this century. As offices grew in size, efficient decision-making processes became more and more crucial to the successful functioning of the

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enterprise. Rationalisation served to centralise this decision-making, which became increasingly identified with the management role. Fordist techniques, although first applied in manufacturing, began in the 1930s to be emulated in office work. Standardisation of work procedures, the reorganisation of office layout more on flow-line principles, and time and motion studies, were introduced as a means of increasing efficiency and productivity. Planning and co-ordination became centralised, thus removing decision-making from the lower levels of clerical work and forming the technical basis of management authority. Thus this attempt at Fordist rationalisation went hand in hand with the growth of the management role, even though levels of mechanisation were very low, being restricted to the typewriter, telephone and dictating machines.

This rationalisation partly resulted in the division between typing and secretarial work through the formation of typing pools. In Britain typing pools existed as early as the late 1880s, although it was not until the dictaphone came into widespread use in the 1920s that typing pools became the most common working arrangement for typists (Benet, 1972). A dictaphone allowed the physical separation of those who dictate from those who carry out the transcription from tapes, the audio-typist. Centralisation of the typing function within the organisation was believed to increase overall productivity, particularly that of the typists themselves.

Of course there is a considerable *variety* in clerical work in which each document may require some different processing. The low machine intensity remained until the 1960s when xerography and computers began to come into routine use.[4] These factors limited the applicability of Fordist standardisation techniques for increasing the productivity of office work over and above that gained by increasing the intensity of work through application of the division of labour. Attempts to standardise office work were therefore limited in their extent; Braverman is forced to point this out, even against the thrust of his own argument:

> The work processes of most offices are readily recognisable in industrial terms as continuous flow processes. In the main they consist of a flow of documents required to effect and record commercial transactions, contractual arrangements, etc. *While the processes are punctuated by personal interviews and correspondence, these serve to facilitate the flow of documentation.* (Braverman, 1974, p. 312, emphasis added)

The relative applicability of Fordist standardisation is plainly linked to the type of office work in question. The most successful types are undoubtedly the clerical industries. As has been said, in these offices the major activity is the processing of large volumes of information, often in a limited range of formats. So the major technique for the standardisation of inputs – buffering the internal bureaucratic systems and clerical labour process – is the use of forms. Application forms, order forms, cheques, etc., are all a result of the demand for an input in a format which will match the standard operations of the clerical labour process.

An addition to standardisation as a means of increasing the productivity of office work, although coming much later, has been the introduction of mainframe computers for electronic data processing (EDP) which became a commercial reality for most office work during the 1960s. In 1965 eighty-eight local authorities in Britain had access to a computer for administration. By 1976 the number had reached 260. Housing records, payrolls, accounts, engineering and architectural data and police records were put on computers. In banking, EDP lowered the cost of work, reduced labour levels and the high error rate, and, importantly, allowed more effective managerial control. Leavitt and Whisler (1958) had predicted that computers, by increasing the speed and quality of information from low to top management, would weaken the power and authority of middle management. Control of the organisation would thus be centralised. Several later empirical studies supported this view of Dale's:[5]

> As the machines [computers] increase in number and complexity, they give rise to further division of labour to add to those which, originally, they were called in to implement. Their costs rise and as institutions become larger there is a strong tendency towards centralisation; the physical aspect of the office becomes more like that of a factory department and the nature of the routine changes from purely clerical to the manual or technical. (Dale, 1962, p. 81)

However, there have been other views. Withington (1969) argued that computerisation only resulted in greater centralisation in routine areas, such as data processing, and that the tendency toward increasingly complex managerial heirarchical structures was not observed. Instead, some argued that computerisation would promote decentralisation of line responsibility (Likert, 1961). Individual

offices that had an on-site computer, rather than having on-line access to the mainframe at head office, it was observed, had a greater local management autonomy and less centralised corporate authority. So, as the price of computers came down in the 1970s, it was suggested that as many more plants acquired their own computer facilities this would 'not lead to centralisation but foster greater structural complexity and more autonomy at the plant level' (Blau *et al.*, 1976, p. 37).

These accounts of decentralisation tend to confuse the notion of decentralisation of decision-making over an extremely narrow range of issues with the relocation of power and control over the way an organisation is run. As Crompton and Reid (1982) point out, 'decision-making does not of itself necessarily provide a reliable indicator of the location of power'. Instead, they argue, it is the 'capacity to influence or determine the premises upon which decisions are made' which is a more reliable indication of centralisation or decentralisation of power in an organisation. Thus, those studies that argue that EDP-type computerisation has promoted multi-level hierarchies and decentralisation of authority, neglect the fact that *decentralisation* of some decision-making functions may coexist with increasing *centralisation* of other, more strategic, functions. Although various middle managers may be able to take more responsbility for decisions through the availability of more information they do so within pre-determined premises, that is within limits that have been set by higher management.

Thus, computerisation radically affected many jobs in the office and altered its structure and dynamics. Unlike earlier forms of mechanisation, computerisation had a profound effect on the organisational structure. It also required a reappraisal of both data and information flow. The application of mathematical techniques in conjunction with electronic data processing and operational research rationalised decision-making. This directly affected planning procedures and management and often led to recentralisation as many previously separate departments (such as sales and marketing) were reintegrated into a centralised office structure.

In the office, those adversely affected by computerisation were principally the female clerical workers who, with the use of EDP, became key-punch operators. Key-punching became the largest single category of computer-related work, contradicting claims that computerisation would immediately mean a reduction in the number of lower skill jobs (Shepard, 1971). Hoos (1961) studied the impact of

computerisation upon female clerks in the USA and found that former filing and ledger clerks, of whom the vast majority were women, were subsequently employed as key-punch operators. According to Hoos, this work was monotonous and routine, it paid less than clerical work, and there was little chance of promotion. The other jobs created by computerisation – programming and systems analysis – required special training which the majority of women clerical workers would be unable to acquire. Lack of educational qualifications and the responsibility of married women for household tasks and child-care both contributed to the difficulties for women attempting to take advantage of such positions. Further, key-punch work was more easily controlled and measured by office managers than other clerical work. So in conclusion, Hoos argued that there was little evidence to support the claim that what she called 'automation' provided work of greater interest for the clerical workers. Thus it was the bottom group of the office hierarchy which benefited least from the reclassification of office jobs and which today continues to fill those jobs with the lowest status and lowest pay. That bottom group remains almost exclusively female.

There seems little doubt then that some principles of Fordism were applicable to computer-dependent clerical processes, contrary to those who associated computerisation with decentralisation and upgrading. But these early applications of computerised data processing were limited by two factors. The first was that only highly structured operations, such as accounts, wages or administrative functions which could be represented in terms of numerical data, could be easily computerised. The second was the high cost of using mainframe computers, which necessitated the processing of high volumes of data in centralised computer departments.

On the other hand the application of Fordist principles to the highly *varied* work of most offices was not an easy one. In such offices, both in services and manufacturing, which exist outside the large-scale clerical industries, the scope for routinisation and standardisation of procedures has been limited. This is partly due to the smaller scale of office work, which has limited the sub-division of clerical activities such as in typing pools or filing departments. Also, since much of the work is based around *particular* customer requirements (as in the case of service offices) or a physical production process (in the case of manufacturing) the scope for Fordist rationalisation is more limited than in some of the 'clerical factories'. Although office procedures do exist for activities such as

ordering and invoicing, stock control and cost-accounting, a significant proportion of routinised office work is concerned with attempting to fit the information to be processed *into* the procedures, and with subsequent 'trouble-shooting' activities. Thus, although management, operations and customer requirements, in contrast to the 'classical' organisational structure, may be in Strassman's (1982) term 'diverse', the *procedures* to be followed will be standardised. This is particularly the case in retail offices such as estate agents, travel agents, professionals' offices, which have shop-fronts, where the requirements of individual customers or clients have to be dealt with. Where service industries are more highly concentrated, these smaller offices are often satellites of the larger clerical headquarters. As such they can be seen as buffers between customers or clients and the larger organisations – as in the case of the local office of a bank or building society, for example.

Neo-Fordism in Offices

So if Fordism, dependent for its success as a form of production on standardisation, has had only a limited application within office work, what difference is made by the arrival of new computerised technologies of a much less centralised and fixed type than the mainframe computers of the 1960s? Despite the familiar claims that electronic word-processors (the most common piece of computerised new technology to be used in offices) would upgrade office workers by eliminating tedious routine tasks like the repeated retyping of corrected documents, it has been argued by some authors that such equipment has *intensified* prevailing trends, making Fordist forms of work organisation easier to install and increasing the division of labour and speed of work.[6]

A word-processing system can be described as a combination of equipment and personnel, working in an environment of job specialisation and supervisory controls, for the purpose of producing typed documents in a routinised, cost-effective manner. Given this classical Fordist description, it is unsurprising that little has been claimed, either by manufacturers or the management literature, regarding the enhancement of *typists'* work with the use of word-processors; this is in contrast to the favourable predictions concerning the effect that word-processors would have upon *secretarial* work. What is usually claimed by manufacturers of word-

processing systems is that they make a typist's work easier. However, this must be offset by the effects of standardisation, fragmentation, increased work load and supervision.

When word-processors are introduced into a typing pool the overall effect is to rationalise clerical production further and to intensify work. This process begins with an initial work study and continues with the automatic monitoring and increased supervision of work. As Softley (1984) describes:

> Before a company decides to purchase a word-processing system it will usually undertake some form of work study, entailing detailed accounting of the work being carried out in the typing pool, e.g. the number and type of documents typed per day and the number of separate revisions per document. If the decision to purchase is made then the results of the work study are used to standardise the form in which the work reaches the centre.

For instance, an insurance company had to rationalise a hundred different types of forms so that a few standard layouts could be placed in the word-processor memory. Another insurance company failed to do this initially but soon realised that productivity increases depended on standardisation and began to alter the layout of the forms they used. If an organisation is intending to set up communications systems between its different branches, then a standard format in all offices would be even more necessary. Another consequence of standards however, is the control they give to supervisors and management over production- and work-scheduling. Standardisation of work also facilitates greater fragmentation of tasks. In shared-logic or distributed systems, where each terminal is linked to a central processing unit, work can be automatically transferred from one typist's terminal to another. A group of typists can then handle one long report simultaneously, thus increasing the division of labour in the pool. No longer do individual typists work through a piece of work but, depending on demand, they are required to work on parts of other documents without necessarily seeing the beginning or end of it, or knowing anything about what it is they are typing.

Nevertheless, standardisation of work does not necessarily mean a decrease in the variety of the work performed. The majority of word-processor operators in Softley's survey indicated that word-processing had increased the variety of their work. It could be argued that the incorporation of word-processing into typing systems is a

relatively recent phenomenon so that any changes now being observed may be purely transitory in nature. Yet, this increase in variety has also been reported in the USA where the average length of time a company had used word-processing was five years compared with two in Britain. The observed increased variety of work can be best explained by reference to the way work is organised in a traditional typing pool where tasks are already standardised and fragmented. An increase in variety in the move from typing pool to word-processing centre may simply indicate that different types of work are now being carried out, although the rules and procedures for completing each category of work remain standardised.

Even though electronic word-processors seem to have exacerbated the Fordist aspects of typing pool work, it must be recalled that not all clerical workers are engaged in full-time typing so alternative forms of work organisation have to be envisaged. In the early 1970s when word-processing was first being introduced into the USA on a large scale the division of secretarial work into its typing and non-typing components, followed by centralisation of the typing/word-processing function, was indeed seen as the most cost-effective way to increase productivity. Discussion in management journals focused on the efficiency of word-processing centres that could handle the typing needs of the whole organisation. The typists, or word-processor operators, in these centres became known as 'correspondence' secretaries. The remaining secretarial support was provided by groups of 'administrative' secretaries, who carried out filing, telephoning and reception work.[7] Thus, the centralisation extended to the secretarial function. Sometimes secretaries would have typewriters for short memos, otherwise all material for typing would be sent to the word-processing centre.

In terms of the typing function, such centralisation represents a highly rationalised arrangement – the word-processing centre usually being administered by the office services department. In many companies, however, there has been considerable resistance to the idea of centralised control over word-processing departments. Individual departments and divisions often want to retain control over various aspects of the word-processing centre's work – in particular supervision and prioritisation of work – leaving the office services department responsible for system and job design, installation of the equipment and training. In the USA, there has been a move *away* from full-scale centralisation. Softley (1984) reports a company which, in the initial enthusiasm surrounding the introduc-

tion of word-processing ten years ago, set up a word-processing centre. It was soon discovered, however, that one centre did not provide enough flexibility. Problems arose with the scheduling of material and the long turnaround times, even for such things as notes and memos. A few years later, the secretaries, who had been grouped into administrative centres, were given back their typewriters and the correspondence centre was split into three smaller ones. The word-processing centre had been decentralised.

In Britain, the introduction of word-processing has not so far meant much large-scale organisational change. For the most part, companies have simply switched from centralised typing to centralised word-processing (Manpower Services Commission, 1982; Steffens, 1983). At the time of writing, word-processing is just beginning to have some impact on the work of British secretaries. In small to medium-sized companies the quantity of repetitive typing work carried out by personal secretaries does not usually justify the purchase of a word-processor and in other organisations secretaries have access to a word-processor but are not usually employed as full-time operators.

It must be remembered that electronic word-processors are only one component of computerised office equipment that is likely to be introduced into offices over the next decade. The other equipment – particularly desktop computers and intelligent telecommunications devices – will be significant in boosting the productivity of office workers who are not typists. As Strassman (1982), a senior executive with Xerox, the office equipment company, put it, '(Such equipment) can compress the time for completing work . . . by altogether eliminating many labour-intensive office tasks performed by craft specialists whose burdensome and sometimes frustrating jobs are now embedded into the electronic workstation by means of software'.

Just as with manufacturing industry, some writers have suggested that non-Fordist types of work organisation are more appropriate for the operation of these high variety computerised technologies if maximum efficiency is to be obtained from them. However, there have been fewer studies of such alternative forms of job design for office work than for manufacturing work. Mumford is one of the most prolific writers on this subject. She has carried out several studies of the introduction and design of computer systems (Mumford and Henshall, 1983; Mumford, 1983; Mumford, Land and Hawgood, 1978). Like socio-technical systems theorists (see Chapter 5) Mumford argues that the structure of workgroups need not be determined

solely by the technological system, but that a fair degree of 'organisational choice' is possible, allowing the formation of non-specialised, but integrated, workgroups. Designing work systems in this way is supposed to increase job satisfaction for the workers concerned, and the involvement of workers in the actual design of work systems is a key feature of Mumford's approach. Most recently Mumford has been involved in the design of word-processing work systems in private companies, where unionisation among typists and secretaries is low.

Mumford uses the concept of a 'design group' in her work, meaning a participative approach to changing work methods which aims to balance the efficiency needs of the organisation against worker satisfaction. Systems should be designed which are not simply concerned with the choice of computer hardware but also with the overall organisational system, 'which includes a network of people carrying out a variety of roles and having individual and job satisfaction needs' (Mumford *et al.*, 1978, p. 2). The design process is therefore much more extensive than was envisaged when early training programmes for systems analysts were conceived: 'It requires of the system analyst an ability to identify and specify both organisational and social needs and to create a socio-technical system that facilitates the achievement of these needs' (ibid). The design process uses several of the standard analytical/design tools that have been traditionally used by socio-technical analysts, but by arguing for a group participative approach to the design, evaluation and implementation of new systems, Mumford departs from the standard way of designing work systems.

The design process has been applied by Mumford in the redesign of a system at ICI's central management division. A video, *Reliving the Journey*, has been made of the process. Between them the ICI secretaries work for over fifty managers. With such a heavy workload, the word-processors that had been installed were in constant demand and problems arose with the scheduling of work. The video describes how the secretaries analysed their workloads and decided on the most appropriate work-scheduling process (Mumford, 1983).

In another project, involving clerical workers at Rolls Royce's Derby plant, Mumford set up a programme of workers' involvement in the design of a new on-line computer system. A design group was set up composed of workers from the departments involved in the reorganisation, together with a steering group made up of middle and

upper level management and a trade union official. After studying various alternatives, the design group drew up three system designs which were submitted for comments to both clerks and management. One version was then chosen and implemented. Kraft (1979) has criticised this approach because the clerks were not given the choice as to whether they wanted a change or not, the members of the design group were selected by management rather than being elected by their fellow clerks, no mention was made of issues such as job security and work loads and the trades union was relegated to only a minor role. In the event, management agreed to implement an alternative favoured by the clerks, but only as a short-term measure, for they intended to introduce their favoured system 'when the clerks had got used to the autonomous group concept' (Mumford and Henshall, 1983, p. 75).

Kraft's criticisms show that the libertarian, work-humanising ideologies of job redesigners like Mumford are severely constrained by the realities of management power and prerogative, but this is partly beside the point. What is important to managements eager to get the maximum productivity benefits out of new technology is that their workers should be sufficiently flexible in their approach to work-load scheduling. The reorganisation of work around 'autonomous work groups' is simply one means to this end. Of course, some employees and their representative trade unions may have objections to such new forms of work organisation, particularly if they imply a reduction in employment or some uncompensated increase in overall work-load or some alteration of demarcation lines. This is why job redesign, in office work as well as in manufacturing, is easier to carry out where trade unions are non-existent or weak or under strong pressure because of some unfavourable competitive situation in their firm.

From the viewpoint of managements, the successful economic introduction of information technologies requires some new forms of work organisation – one of the elements of neo-Fordism – and it is the opposition of workforces committed to the institutionalised divisions associated with existing 'craft' or Fordist labour processes that managements must seek to overcome. The job redesign procedures advocated by Mumford for office work based on computerised technologies are a means of seeking to engage the commitment of workers to more flexible working arrangements which must go with technologies that raise the productivity of high variety labour processes. Autonomous work-groups, implying the

participation of workers in the design of their jobs and in the allocation of work tasks require a more wholehearted commitment to the overall production process than might be expected by the application of more coercive Fordist principles of labour division and task allocation associated with standardised work routines. Such a view is implicit in the idea that 'future administrative systems' using information technologies will possess:

> greater diversity in procedures that can readily be customised to respond to the need of diverse customers. This diversity in procedure is built up by combining standard modules of know-how, usually incorporated into software, together with an increased amount of choice made possible through individual initiative and through work group co-operation. (Strassman, 1982)

The use of autonomous work-groups is however not the only form of non-Fordist organisation that can be envisaged using information technologies to handle information. If close contact between members of the group is essential to the work they perform then group working will be particularly appropriate. But advanced telecommunications technologies make it possible for much clerical work to be done in a geographically dispersed manner with centralised monitoring and co-ordination of the 'remote workers' who will be 'teleworkers' working at computer terminals in their own homes.

Huws (1984) reports a number of examples of teleworking in Britain and the USA. Whereas most teleworkers at the moment tend to be higher professionals, often working freelance within the computer industry itself, there is a growing, if still small, number of non-professionals. Some are involved in 'offshore information processing'. American Airlines, for example, closed down its data entry operations in Tulsa, Oklahoma in 1983 and hired 200 Barbadians to do the work, using a satellite link between the Barbados workers and the Tulsa data-processing centre. (In the age of modern telecommunications, everywhere it seems is less than twenty-four hours from Tulsa! (Pitney, 1963)).

Given the prevailing sexual division of domestic labour, most of the teleworkers Huws surveyed were women, almost all with child-care responsibilities. Telework then, although convenient for otherwise housebound women who wish to work for wages, has many of the disadvantages of domestic outwork – isolation, unsocial working hours, inadequate technical support, no fringe benefits.

Such arrangements are however highly advantageous to the subcontracting firms. Huws reports:

> (One firm) estimates that homeworkers produce about 30 per cent more than office-based workers in the same time, while ICL claims that twenty-five hours work in the home is equivalent to forty in the office . . . Another important advantage of employing homeworkers was the reduction in overhead costs. These did not just consist of floorspace, heating and lighting, but also included administrative support services and, where homeworkers were self-employed, perks such as company cars, subsidised meals, BUPA and pension schemes as well as holiday, sickness and maternity pay. Flexibility of working hours was also cited as a positive feature of employing homeworkers. This was particularly important in the jobs which made major demands on central data-processing facilities, since work could be timetabled to fit in with times when there was spare capacity on the computers, and off-peak telecommunication charges applied. (Huws, 1984, p. 16)

But there are also a number of disadvantages – monitoring and supervision of non-routine homework is more difficult than when workers are on the organisation's premises. Obviously, telework's future is dependent on whether techniques of remote monitoring can be devised, as well as on the complex calculus, by firms and by potential teleworkers, of factors such as the relative costs of telecommunications, office rents, transport to work and wages.

Conclusion

To summarise this section, whereas it has been possible to transform the production of some clerical work services along Fordist lines, this has generally been limited by the degree of variety of the clerical work concerned. The success of such transformation and reorganisation has been strongest in those services which could be described as clerical industries. These include services like banking, insurance and finance, mail order and public administration. In general, other clerical work has proved much more difficult to reorganise along Fordist lines, and as yet, the computerised office technologies in use in offices have tended to be restricted to one part of the clerical process – typing. The integration of separate pieces of office equip-

ment, within and between offices, and their diffusion into many more service sectors – in short the increased use of flexible office equipment – will permit all sorts of 'information workers' to perform a wider array of non-standardised tasks at higher productivity levels. This suggests that the limitations of Fordist applications might be transcended. This will be especially the case if new concepts of job design are widely adopted or if telework becomes more acceptable. Together one might characterise these changes as neo-Fordism in clerical work.

THE RESTRUCTURING OF SERVICE PRODUCTS

However, the application of such neo-Fordist principles to the organisation of clerical processes in the production of the services is not the sole way in which the limitations of Fordism can be overcome; indeed, although it is certainly important in the short term, we are of the view that there are much more substantial changes in service provision that can be envisaged. In other words, the services could also be transformed by changing the way in which they are delivered, that is by changing the form of the service product itself. This can be done in two ways: by *externalising* part of the service labour, shifting it on to the consumers themselves; and, more dynamically, by changes in the *kinds* of services which are offered to satisfy human needs. We elaborate on each of these in turn.

Externalisation of Service Labour

One way round the problems of significantly raising labour productivity in services is by the externalisation of the labour of providing the service. Thus, rather than provide the service 'in full', service production takes the form of providing the users with the means to provide the service, to varying degrees, for themselves. The user contributes some of the labour, unpaid, whilst capital provides the means of production! The externalisation of labour can take various forms. One form is that of reorganisation of service industries so as to incorporate a *self-service* element, familiar examples of this being in restaurants and supermarkets. Here, it is the equivalent of the *assembly operations of Fordism* which are externalised. Going around a supermarket, shoppers assemble their particular basket of

goods from the module of components which are presented to them by waged service workers (shelf-fillers, stock controllers, etc.). Similarly, in a self-service restaurant a meal is 'assembled' from a choice of components. Other consumer services such as banks and libraries are adopting this technique, organising the self-service activity around information technology (such as cash points).

The transformation of the labour process in the delivery of services is probably most developed in the case of supermarket retailing. This process began in inter-war America where use of self-service spread horizontally to practically all types of retail stores; only later did these techniques diffuse through British retailing (Dawson, 1981, p. 22). The development of supermarkets in the USA during the 1930s depended not only on the provision of private transport and a developed road infrastructure to enable the volume of sales to be increased, but also on the availability of standardised products. The prepackaging of food by canning and wrapping, along with the use of refrigeration and preservatives to ensure shelf life and also the grading of perishables, allowed a wide variety of goods to be available from different suppliers. Yet externalisation of labour allows the sloughing off of more labour-intensive bespoke work, the assembly of different individual baskets of goods, on to the consumer. In retailing then, the servicing tasks of selling, weighing out, bagging and standardisation of products, are displaced from the retailer to the supplier, whilst the selection, retrieval of goods and delivery are shifted onto the buyer with self-service and cash and carry; so the economies of scale of supermarket retailing only capture part of the rising productivity of retailing, the other parts being accounted for by self-service, together with food-processing and packaging developments.

A similar case is that of catering, where the assembly line of the cafeteria resembles that of Fordist production processes. There are analogous problems of sequentiality and line-balancing just like the assembly lines in production, since the speed of the line is dictated by the slowest customer and bottlenecks often occur. Currently several of these cafeteria systems are being changed from one single line to several mini-lines for different parts of the meal (meat dishes, fish dishes, sweets, drinks, etc.) in an attempt to overcome such problems. Such reorganisation of flow-lines is similar to parallel flow reorganisation in production assembly, detailed in Chapter 6. Note that supermarkets do not face this problem since customers are not bound to follow a prearranged route through the supermarket; they

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can vary their route according to the desired constituents of their shopping baskets. In this sense the supermarket and reorganised cafeteria have more in common with neo-Fordist forms of organisation than Fordist ones. The exception to this is, of course, the check-out queue. It is to this bottleneck that computerised technologies such as electronic point-of-sales systems are being directed.[8]

The introduction of computerised information-handling systems makes externalisation possible in some other service industries. Most notably, the rapid diffusion of automatic tellers/cashpoints inside and outside banks can be seen as a way of increasing the productivity of bank workers by mechanising simple monetary transactions. One can envisage similar developments in such labour-intensive services as ticket sales, food and drink vending and non-complex information and advice dissemination.

The Restructuring of Consumption

An an alternative to externalisation, the means of production of services can be sold direct to the user in the form of a physical commodity. This has already been an aspect of the Fordist restructuring of consumption. Rather than producing the means of production for the collective provision of services, some industries have concentrated on the provision of consumer goods for individual or household consumption. To explore this further we will briefly recapitulate and extend some of the ideas of Aglietta presented earlier in Chapter 3.

Aglietta characterises the historical development of capitalism in the USA as a regime of extensive accumulation in the nineteenth century followed by a regime of intensive accumulation, which was constituted politically in the 1930s and 1940s in the New Deal and in World War Two and generalised world-wide after the war. But Aglietta's major contribution is his description of this shift as a 'simultaneous revolution of both the labour process and the conditions of existence of the wage-earning class' (Aglietta, 1979, p. 20), together constituting a Fordist regime of intensive accumulation. Aglietta therefore sees Fordism not only as a set of principles for organising a production process in a particular way but also as involving the fact that *consumption* of those products has to be 'organised' to guarantee profitable sales of the mass-produced items.[9]

This change in the 'conditions of existence of the working class'

came about through the development of a homogenised mode of consumption based on the commodities from old and new branches of production organised along mass-production lines. The change took place in two phases. First, the depression of the 1930s is explained as a crisis in the extension of the norms of consumption from the rising 'middle class', who were the main markets for the growing new consumer industries of the early twentieth century, to the working class who so far had not significantly participated in purchasing these new products. The New Deal in the USA and the adoption of Keynesian welfare state policies in Europe after World War Two restructured capitalist economies from their pre-war depression to lay the basis for a post-war phase of energetic intensive accumulation. Second, the most recent sustained period of accumulation from the 1940s onwards involved the diffusion of Fordism throughout the mass-production sectors of capitalist economies. The potential profitability of this form of the labour process crucially depended on the active construction of economies of scale, and therefore on the restructing of consumption.

While we do not feel that Aglietta's account of how labour process change was linked to phases of economic growth is adequate by itself – indeed the first three chapters of this book constitute an account with a different emphasis – we do agree with him that Fordism implies an analysis of consumption as well as production. He sees the consumption changes as the following:

- *the commoditisation of the means of consumption:* the transformation of domestic household labour activities in such a way as to open up markets for profitable production of consumer goods aimed at the individual household. Examples would be factory-produced clothing instead of home-made; bought and semi-processed foods instead of domestically grown and prepared; the use of domestic appliances and automobiles, etc.
- *homogenisation of this consumption* by means of standardised mass-produced commodities. The economies which this form of production allows undermine the necessity for and economic viability of domestically-produced alternatives.
- *an extension of these consumption norms* to more and more sections of the working class in advanced countries, not least to non-working dependents (the old, the sick).

The developments in the 1930s and 1940s which Aglietta sees as facilitating these trends are:

- an infrastructure of housing, roads and utilities within which a large consumer-durable market could arise.
- collective bargaining, which permitted planned increases in wages and the reduction of working time, especially for white, male, organised workers and established income security for less-well-organised sections of workers.
- welfare systems which introduced a minimum social wage and assisted in the generalisation of the social consumption norm.
- financial innovations – credit, hire purchase – to facilitate purchases.

Thus, by the 1950s and early 1960s it had been possible to generalise Fordist labour processes, extending them to industries producing what were 'luxury' goods before the war. Both old products and new products fitted into the Fordist production norm which was aided by short-life, cheap goods (planned obsolescence) and the homogenisation of oligopolised markets by advertising.

Despite its prolonged success there are progressive limits to the continued efficiency of Fordism. Aglietta, like us, sees these limits as part of the present economic crisis. These exist both in established Fordist production processes, which we have already mentioned in Chapter 3, and in the extension of Fordism to other sectors.[10]

The importance of this analysis for our discussion of the service sector is its emphasis on how the nature and form of some service provision has already been radically changed by Fordism. This raises the question of how further changes in service provision might be brought about, either by development of Fordism or by neo-Fordism.

Aglietta draws attention to the limited applicability of Fordism to reducing the cost of the collective welfare services of health care, education and public administration. Echoing some British monetarist writers, Aglietta suggests that the low growth in productivity, but rise in real wages, in these labour-intensive service sectors has acted as a brake on accumulation. This can only be resolved by 'radically transforming the conditions of production of the means of collective consumption [the welfare services]', renewed accumulation only beginning with 'a massive transformation of unproductive labour into labour productive of surplus value' (Aglietta, 1979, p. 157).

A similar analysis of services, though not situated within the development of the organisation of production or within broader politico-economic factors relating to the progress of capital accumula-

tion, has been put forward by Gershuny and Miles (1983). They argue that over the past fifty years major service functions have been affected by a change in the pattern of service consumption. The transport service function, for example, was satisfied in the 1930s by a transport service industry of railways, buses and trams, privately- and publicly-provided, which offered many people occupations in the transport service. Technologically, the industry combined these occupations with heavy machinery (the trains, the buses) within an established physical infrastructure of the railway and road systems. These combinations of technology, infrastructure and specific social arrangements Gershuny and Miles call 'socio-technical systems' (not to be confused with the identical term for a type of work organisation, as discussed in Chapter 5).

In the 1980s, however, there is a strikingly different socio-technical system of transport service function provision. Whereas collectively-used transport service industries are still in business (and now embrace air travel as well) there has been a shift to the satisfaction of this function by 'self-service' modes. Encouraged by the cheapness of mass-produced commodities, individuals now purchase hardware from the manufacturing sector (namely cars in this example) and drive them themselves, in effect using their own unpaid labour. The balance between the formal service industry provision of transport and its 'informal' self-service provision has shifted. The service function has become 'privatised' in the sense that every household is encouraged to purchase its own car. What follows is falling employment in the public transport service industry and, until recently, rising employment in the manufacture of transport products. Gershuny and Miles argue that similar shifts have occurred in the satisfaction of other service functions – particularly in the domestic, entertainment and communications service functions, which are now reorganised around manufactured commodities.

In entertainment, direct entertainment (theatre, cinema) has been replaced by broadcasting and receiving equipment and video- and audio-recording and playback equipment with associated software – TV programmes, records, video tapes. In the domestic services, the balance has shifted, notably with the provision of domestic appliances but also with 'do-it-yourself' equipment for other domestic services such as building maintenance, decorating and appliance and car repairs. In short, the parallel development of production and consumption based on Fordist industries has acted to expand and

transform consumption of entertainment, transport and domestic services away from provision by service industries towards the consumption of goods.[11]

The transformations in these service sectors has been termed by Gershuny and Miles 'social innovation', based on the growth of what they call self-servicing (to be distinguished from the form of self-servicing described earlier as 'externalisation'). The penetration of service sectors and their transformation by, originally American, large capital has been indirect through the marketing of mass-consumption products rather than transformation of the existing service industries themselves.

A necessary condition of this development, as we have already pointed out, was the provision and extension of particular infrastructures on which the mass-produced commodities of cars, domestic appliances and electronic consumer goods were dependent; public roads and later motorways, the national utility networks, the broadcasting network. Of course, this domestic consumption was also linked to the increasing provision of adequate public and private housing over the post-war period.

Despite the relative decline of service industries providing equivalent functions to those of the new mass-produced commodities (public transport, domestic services, cinemas and theatres) a new type of service grew – which Gershuny and Miles have labelled 'intermediate consumer services'. Unlike the provision of service functions taking the form of final consumer services, intermediate consumer services involve servicing the new forms of consumption: for example, domestic appliance repair and maintenance, broadcasting stations, garages and recording industries. In the case of record and, later, video industries, this intermediate service involves the production and sale of goods, such as records, audio tapes, video tapes, as a physical vehicle for the 'software' service, as distinct from broadcasting which provides the software instantaneously rather than in the form of a material commodity.

One crucial difference between the purchase of services and the consumption of service-replacing consumer goods lies in the provision of labour needed to produce the final service. In the case of 'social innovation' the labour is ultimately supplied by the consumer. The 'labour-saving' effect of domestic appliances on domestic labour is a form of labour externalisation in service functions.[12] Rather than enter and transform the low-productivity traditional service sector of, for example, laundries, domestic decorating or repairs, passenger

transport or live entertainment, capital investment took place instead in mass-production of consumer goods.

So the transformation of service functions by the use of Fordist products is complex. It fulfils certain needs (mobility, washing clothes, leisure, etc.) by means of a changed product but it also assists certain types of firms differentially because of the relative ease of increasing productivity and profits in, say, automobile engineering as compared to transport services. Also, the total level of demand for service functions is expanded by channelling consumers' needs into the profitable consumption of Fordist commodities, rather than the use of collective services. The problem of increasing the productivity of labour in service industries is, in effect, circumvented by externalising the necessary labour from the formal (paid) to the informal (unpaid) sector. The question now is: do information technologies make such developments more 'attractive' in other service sectors?

Restructuring State Services

The group of services least affected by the developments discussed so far are those provided by the state. Authors of many conflicting ideological persuasions agree that any long-term economic upswing in advanced capitalist economies – at any rate an upswing which maintains the essential features of the capitalist mode of production – is threatened by the large proportion of the national product which is spent on state-provided services.[13] These services may be thought of as welfare provisions, but they are also essential for profitable industry insofar as they generalise the costs of the 'reproduction' of the workforce. They provide education, training and health care for the workforce of today and tomorrow, and services like rubbish collection, sewage treatment, roads and energy supplies, which maintain general social health and offer cheap means of production and distribution for the output of private industry. As a result of the enormous social, health and environmental problems which the rapid industrial growth of the past thirty years has produced, other services have grown to deal with the diseconomies of capitalist production. Hence there has been the growth of regulatory services to deal with pollution and environmental problems, of planning services to attempt to bring some order to the otherwise anarchic locational decisions of modern corporations and of social work services to police

and provide sustenance to those who do not quite fit the personality requirements of the modern good citizen. Added to this, for some countries, is the enormous cost of providing military arsenals to protect the perceived interests of the advanced capitalist states.

The emergence of the welfare state in Britain after the 'post-war settlement' involved an acknowledgement by the ruling class, via the state, of the inability of market mechanisms to fulfil certain social needs – particularly those associated with the reproduction of the labour force and the maintenance of the non-working population. It was a result both of class struggles for improved housing, health and education and of a perceived need for more instruments of social control (Gough, 1979, p. 52). The post-war Welfare State took on responsibilities for the provision of collective social services, which have in turn undergone a fairly continuous growth during the post-war boom. The growth of collective provision in education and in medicine contrasts with the reduced provision of those collective services providing parallel facilities in transport, entertainment and domestic services which, as we have already argued, were the main targets of the Fordist production of consumer goods.

In fact, the collective services of education, welfare and medicine are less amenable to commodity substitution than those of transport, entertainment and domestic work. They involve large elements of professional work which has acted as a brake on social innovation in the provision of such services. There are some examples of commoditised, self-service varieties, such as home instruction courses, community care schemes and patent medicines but these form the minority of service provision. A second function of such services provided by the state is that of ensuring social control and the adequate reproduction of the workforce. In the case of welfare services especially, but also in large parts of education and medicine, state responsibility reflects a broad concern with ensuring particular standards of child-care, socialisation and health. This often involves the support and policing of family units, these being the preferred site of social reproduction. Institutions of education and medicine have been developed so as to augment rather than replace the family as a fundamental site of reproduction. So total service provision (for example, children's homes or long-stay hospital wards) are seen as necessary only when family-based provision is declared inadequate by state functionaries. Hence the scope for self-service, commoditised replacement of state services has been limited by the need for the state to exercise social control functions via professional agencies.

As the economic situation has deteriorated, increasing pressure has been felt to restructure this pattern of state services in all advanced capitalist countries, though to different degrees. This has come from various sources, which include:

- political parties and parts of the state itself. Monetarist strategies to reduce the overall level of state expenditure have resulted in cuts in state services and attempts to increase the efficiency of welfare services like medicine, social services, education, cleaning, refuse collection and public transport.
- private service companies, especially in the areas of cleaning, catering, security, refuse disposal, etc. who see their market shrinking because of the downturn in economic activity in the private sector. They see the public sector as a potential area of growth.
- capital goods manufacturers, who see the mechanisation of parts of the service sectors as possible markets for their new computer-based and high technology machinery.
- the users of services who see the often unresponsive and ineffective services provided by the state worsen as cutbacks and spending limitations reduce the adequacy and level of provision of collective services.

The outcome of the conflicts between these competing forces is obviously unclear. One thing *is* clear: the level of state expenditure on the services provided by the state is unlikely to maintain the rate of increase of the past decade over the next one. What sort of changes might be expected in the functions at present provided by the state?

An important dramatic change in recent years, particularly in Britain, has been the significant entry of private capital into the area of the economy previously accounted for by the state provision of collective direct services. For example, the private health care business in Britain accounted for £330m in 1981. Large service companies operate at an international level in the fields of cleaning and catering: for example, operating huge service-contracts in the Middle East and Mexico supplying street-cleaning, refuse or large-scale catering. Furthermore it has been government policy in Britain deliberately to force the introduction of private firms into state services in an attempt to reduce expenditure on them. Thus recent government directives have been issued to force health authorities in the National Health Service to award contracts for ancillary services such as cleaning, laundry and catering. At present private firms are

competing against the public provision of these services at the expense of the wages and conditions of their workers and the quality of services provided. This has been found to be the case especially in cleaning. Commercial catering is becoming more capital-intensive with the introduction of 'cook and chill' and 'cook and freeze' systems of meal-preparation. This form of catering has applications in industrial and public catering and is also being considered as a replacement for school meals, as well as replacing meals on wheels (provision of meals in a state-funded voluntary service for the elderly and housebound).

The entry of capital into new sectors and the subsequent increase in capital-intensity is a well-established process within manufacturing but collective services are now experiencing changes along these lines too. The use of television monitors and electronic surveillance techniques in security work and the use of computers to optimise the movements of vehicles in refuse collection or public transport are further examples. It is not necessary for privatisation of services to take place before such transformations can occur. Capital-goods suppliers often have an important role in diffusing new techniques and technologies. (For example, British Oxygen Company, suppliers of liquid nitrogen, have strongly supported the development and use of 'cook and freeze' technology.) And these state services tend to have certain features which are ideal for technical and organisational changes, such as guaranteed, large and continuous markets for their services, attributes particularly appealing to private contractors, whose access to finance is greater.

RESTRUCTURING HEALTH CARE SERVICES

Introduction

We do not intend to explore all the possible scenarios for the transformation of state sector services here.[14] In the remainder of this chapter we will use one sector as a 'case study'. The role of information technologies in health care will be a useful example for some speculative discussion of how service provision might change in the future.

We should emphasise that our discussion *is* speculative. The technological developments we describe are not necessarily very well advanced in the sense that they are likely to diffuse rapidly

throughout the health-care sector of any advanced capitalist country. Such diffusion would anyway require substantial changes in the organisation of the institutions which currently provide health care (such as the National Health Service – NHS – in Britain) in the attitudes of the medical professions to certain medical technologies as well as substantial public investment in the appropriate telecommunication infrastructures. These changes will not come about because developments in information technology 'demand' them; they clearly involve complex professional and political struggles. However, we seek to describe some of the strategic 'options' for the development of health-care services in advanced capitalist countries (although we focus principally on Britain) as seen from the perspective we have developed in this chapter – namely, the restructuring of services taking advantage of the economies offered by information technologies in the context of solving the long-term structural economic crisis of capitalist countries.

Over the past ten years, governments in all advanced capitalist countries have sought to slow, or even reverse, the growth of welfare expenditure by a variety of means. They include: the closure of inefficient facilities (rationalisation); an increase in the efficiency of ancillary services (such as laundry and catering) either by better management methods and the use of less labour-intensive equipment or by subcontracting these services to more efficient outside agencies (called 'privatisation' in Britain) and reforms in the management and financial structure of the services so as to introduce stricter cost-accounting methods.

The increasing cost of medical care has proved a problem for both the state-provided service and the private, profit-making sector; in the latter, increasing competition between private companies providing health insurance which funds the majority of private health care has put pressure on private hospitals to economise. The effect of these competitive pressures has been varied. One major factor differentiating private from public provision has been the quality of cost-accounting information available in the former. This allows high-cost procedures, both medical and administrative, to be identified more easily for cost-saving. As a result, even private hospitals are beginning to realise the dominant role that senior hospital doctors play in determining the costs of medical treatment (*Financial Times*, survey, 24 January, 1984).

In health care, the organisational changes that are under way also have a technological dimension, in both the administration and in the

delivery of care. In administration for example, computers are being used in resource management to facilitate better planning. They are also used in keeping records of patients and in scheduling appointments. Such developments are extensions into medical administration of computer hardware and software applications already in routine use in other spheres.[15] But it is in the delivery of health care that the most interesting and socially significant technological innovations are taking place.

Much attention has been directed towards reducing costs by changing methods of surgery, the most profitable area of medical care in the private sector. This can be done either by the introduction of capital-intensive high technology medical equipment or by a expansion of day-care facilities, reducing the overheads of twenty-four-hour nursing care (currently around £100–£200 per night). New techniques which simplify surgical routines, such as the use of lasers, or even remove the need for surgery altogether, as in the use of the lithotripter to remove kidney stones, can be used to cut both surgery and after-care costs.[16] Also the profit-making sector has a role in trying out new technologies and care techniques, even though the use of such techniques in private medicine may be for marketing reasons, to give a 'high-tech' image, rather than because it has proved efficacious (see Thunhurst, 1982, pp. 43–6).

The process of transformation of the state-supported health care sector by private medical capital is likely to be a difficult business. As the critics of the growth of private medicine alongside the NHS in Britain have noted, much of the growth depends on the satisfaction of lucrative markets such as acute surgery at the expense of the NHS, in terms of the use of its trained staff and facilities (Iliffe, 1983). At present, resistance to the development of the private medical business within the public sector has led to the growth of the private sector outside it. Hence the massive burst of private hospital building in Britain over the last few years, which has doubled the number of private beds. Current attempts to reduce National Health Service costs revolve around the privatisation of ancillary services but this would still leave much of the medical core intact. To transform that would involve a major reform of the professional powers of doctors and, ultimately, consultants.

One proposal which has been mooted for this purpose is the replacement of the current managerial committees involving administrators, consultants and nursing officers in the NHS by professional managers. Such a radical proposal is sure to meet with resistance

from senior doctors as well as from those workers in the NHS who favour more democratic forms of organisation. However, in private hospitals, such a management structure is more likely to be implemented particularly in the profit-making hospitals. In fact, current state policies in Britain seem to be directed at dissolving the barrier between private and public provision rather than dismantling the public service as such. So the outcome of these developments and similar ones in other countries is open. In some countries we may see a two-tier system of health care emerging, much like that in the USA, with a large private sector backed up by a rundown public sector acting as a welfare 'safety net' for the poor. Alternatively, there may be a restructured universal service, although perhaps provided in large part by private medical firms under overall state regulation. A more preferable outcome might be a better-funded and more responsive public service under wider democratic control.

Information Technologies in Health Care

Apart from the technologies of in-hospital patient treatment, there are technological developments based on information technologies which are of interest for the longer-term restructuring of health services: computer-aided diagnosis, automatic analysis and remote monitoring of patients. We elaborate on these in turn.

Computer-aided Diagnostic Systems

Computer-aided systems of diagnosis are already used in a variety of contexts in the formal health care system.[17] Such systems can be used as computer-aided learning techniques for training medical personnel. In health care itself they can be used to collect information from patients in advance of any professional diagnosis in a hospital or in a doctor's surgery or to assist doctors by calculating the relative probability of various diseases from declared symptoms. Computer-aided diagnosis has been shown to work in hospital environments at levels of comparable accuracy to diagnosis performed by doctors. There are also savings to be made by reducing the number of operations and tests which are otherwise performed unnecessarily. There are economic incentives which could stimulate the wider introduction of computer-aided diagnosis into the formal health care

system. Diagnosis could be done more quickly, thus increasing the productivity of doctors or alternatively, diagnoses could be made more simply and could be performed by lower salaried para-medics.

However, the speed with which such systems are introduced will depend on institutional factors, such as the attitude of the medical professionals and on the technical constraints of the kinds of computer programs that are developed. There are two general methods of computerised diagnosis. One – the 'statistical' method – needs a certain level of clinical knowledge on the part of the doctor to interpret the computer result. In contrast, the 'logical' method requires the patient to provide information in answer to video-screen questions, as the program runs. The computer then produces its own result. So in principle, such programs could be run by GPs, para-medics and even by patients themselves rather than only by specialist medical consultants. The program would then be using the model of the doctor's analytical techniques, in a so-called expert system, which could be used by non-expert diagnosticians.

Automatic Analysis Equipment

Much of this equipment is expensive technology for use in hospitals. Examples are ECG, ultrasound and computer tomography and automatic tissue-fluid analysers. But some equipment for use outside the hospital or surgery is also being developed. Electronic machines for the measurement of blood pressure and pulse rate are already easily available. In the USA, ambulatory ECG monitoring for home use has been introduced with a market in 1982 of $85m. Sciencare Corporation launched a pilot compact ECG monitor in March 1982. This device is worn by the patient twenty-four hours a day; it measures blood presure and electrocardiogram signals which are stored on a cassette tape to be replayed by a doctor at her or his surgery on a specialised scanner. Although each unit is sold for $2000, the cost could drop as the market grows so that it can be used by a larger number of patients. Substantial progress has been made in home blood-glucose monitoring for diabetics. Blood glucose-monitoring machines are micro-electronic devices which use a photo-electric method of measuring the reflectance of reagent strips before and after staining with a small amount of blood. These tests can be done by the diabetic at home or at work and replace or supplement urine-testing which is less accurate and less convenient. Since the introduction of the innovation in 1978 in the UK, doctors

and patients have realised the value of controlling the blood-sugar level helping to prevent blindness and renal failure which sometimes affect diabetics.

At present the British government is involved in the development of home blood-glucose monitoring machines. The Department of Trade and Industry has supported the firm Hypoguard in its development of a blood-glucose monitor, 'Hypocount'. Hypoguard also manufactures reagent strips for blood-glucose testing and use with the monitor. The company is now using its expertise gained through the development of Hypocount to manufacture micro-electronic counters for blind and partially-sighted diabetics. 'Dia-data' is a unit into which the diabetic enters up to thirty days of readings from the Hypocount, food intake and activity levels. The patient then takes her or his unit to the doctor whose master unit prints out the information with a summary of the patient's condition.[18]

Remote Monitoring

For patients with some chronic illness or longer-term condition (like pregnancy) frequent visits to the doctor or hospital can be inconvenient. This is true particularly if the distance from home to hospital is large as it will be in countries with scattered rural populations (Australia, for example). However, using various electronic devices, many conditions can be monitored at the patient's home, by the patient, and can be transmitted for hospital analysis via established telecommunications systems. We will give two examples from the UK. ECG monitoring of adults with dangerous heart conditions can be done 'at a distance'. Patients, on suffering chest pains, can telephone the hospital and, using an ECG monitor similar to the one already mentioned, can transmit its results down the telephone to the hospital monitor. The doctor can establish whether any heart attack is imminent and dispatch an ambulance if it is. A similar experimental system is in use to monitor the foetal heart in pregnant women. By means of an electronic sonic detector, the woman picks up the foetal heartbeat and transmits it live via telephone or, it is planned, by radio to a hospital computer which analyses the signal to identify any potential malfunction of the foetal heart. The whole procedure takes thirty minutes. The cost advantages of such remote monitoring techniques seem large – even including the cost of telephone calls and the use of computer equipment, each home monitoring costs less

than 6 per cent of the daily cost of a hospital bed (which many of these patients would otherwise have to occupy to be under direct hospital surveillance).[19]

Clearly such developments, insofar as they increase the productivity of the health services, are likely to receive the support of health-care authorities who are trying to cope with slowly growing budgets. As they imply an increase in the capital-intensity of some aspects of that care they will also have some effects on employment and skill requirements in the health services. But they also offer new markets and, wherever the production sites are located, new jobs in the medical equipment, computer hardware and, particularly, software industries. The medical equipment industry is an expanding part of manufacturing. In Britain, the health-care products industry, which includes pharmaceuticals, is growing in real terms by around 7 per cent annually, though certain high technology sub-sectors are expected to grow at a much faster rate than this overall figure. For example, it has been estimated that diagnostic imaging equipment production will have expanded by nearly 180 per cent between 1975 and 1986.[20]

Will the widespread diffusion and use of information technologies of all kinds alter not just the way existing health services 'deliver' their care but also the *kind* of care that will be demanded by the population? Health care as a necessary human need can be satisfied within limits, either by the formal health *services* (like the NHS in the UK) or by other informal systems which tend to rely on privately-produced marketed services or physical products. In this informal system at present there is an increasing emphasis on preventative health care and on 'unorthodox', 'alternative' forms of medical care. Encouraged partly by state campaigns of health education and by the actions of pressure groups campaigning against forms of environmental pollution, there has been an upsurge over the past ten years in participation in various illness-prevention pursuits, such as jogging, gymnasia, sports centres, and increasing interest in lifestyles and eating habits appropriate to good health (more fibre eaten and less smoking amongst men!). While some preventative health measures are costless in that they involve a switch of spending between foodstuffs, for example, many of them involve the creation of new consumption tastes and the growth of some industries with technological change in others. For example, jogging stimulates the sportswear and equipment industries; increased fibre consumption

switches breadmaking to wholemeal baking technologies; all of them stimulate new branches of publishing. In addition in the 1970s there has been a big increase in the number of people seeking health care advice outside the formal system. In the UK, the number of 'approved' practitioners of such techniques as osteopathy, herbalism, acupuncture, bio-feedback and faith healing has doubled over the past five years, to nearly 8000.[21]

The expansion of health services along preventative lines might be the only real way both to increase good health and reduce the cost of medical expenditure in the long run, as Doyal (1979) has pointed out. But although the importance of preventative aspects of medicine in Britain has been recognised by the state in terms of policy – though with little funding – it is the private sector which has moved into this vacuum with most speed.

There are two possible scenarios conceivable in the development of these two health-care systems, the formal welfare service and informal preventative and private advice sectors. One assumes that the balance will remain much as it is now. There will be substantial productivity improvements in the formal sector which, although still a relatively labour-intensive service industry, whether state- or privately-financed will continue to provide for most people's medical needs. (Some of course will still seek unorthodox advice and others (many) will continue to medicate themselves and participate in self-help activities.) The other assumes that whatever may happen in the welfare-service side of health care, the trends to *self-service*, to purchase equipment and information to care for one's own health, will expand considerably, but will also be simultaneously restructured around information technologies.

Over the next twenty years therefore there could be expanding markets for high technology health care products to be sold, not just to or through the formal health services – though this will be large market – but also on a mass-consumption scale to *individual consumers* directly. The development of these markets, implying the manufacture and maintenance of electronic equipment and the production of all kinds of software to run on it, offers the prospects of new employment at the same time as employment in the formal health service may not be growing, although whether such markets will be mass markets is an open question.

The balance actually struck between the two modes of provision of health-care will depend on many factors; a crucial economic determinant however will be the balance of cost between the various

modes. There are currently a number of options available to the would-be patient seeking, for example, diagnosis of some complaint:

1. to seek the advice of a medical practitioner, either in the orthodox or unorthodox sectors;
2. to seek free advice from friends, the pharmacist etc., and if necessary, purchase proprietary drugs;
3. consult medical books and proceed as in 2).

(1), (2) and (3) are in no way new options, the choice between them depending on a variety of factors, including the costs of consultation and of the alternative treatments. Clearly developments in medical equipment might reduce these costs or at least stop them growing. The next two, certain technological developments permitting, *are* new:

4. consult bought or rented computer programs and/or perform routine tissue-fluid analysis/blood pressure (etc.) measurement and self-diagnose; and follow therapy outlined. (This could, of course be some unorthodox therapy recommended by the computer program which was specifically purchased with this in mind; or be a recommendation to consult some medical practitioner.)
5. as (4) but the whole activity carried out at some self-diagnosis centre not necessarily connected with the formal health care system, but possibly provided by private health-check companies.

Clearly (4) and (5) are not economic options at the present time.[22] They rely upon the generalised possession and active use of, or access to, personal computers and on the provision of substantial information technology infrastructures. Although these are being installed and the diffusion of personal computers is becoming more rapid, it remains to be seen whether they could ever be used routinely for anything as sophisticated as the provision of health-care information. A critical technological factor would seem to be the availability of routine techniques of self-diagnosis. As described above, such techniques are currently being developed, although mostly for use in the formal health-care system. Nevertheless there are some signs that larger markets are being sought. Testing and self-monitoring equipment of various sorts is available – particularly for accurate measurement of blood pressure, pulse rate and some body-fluid analyses as well; but it is not yet particularly cheap. The link between hospital computer-aided diagnosis and home diagnosis has not yet

been commercially developed but during the next five years we can expect a growth both in the number and range of such systems, particularly as some of the conceptual problems are attacked by increasing research into 'artificial intelligence' (see Alvey Committee, 1982; Feigenbaum and McCorduck, 1984).

There are already a number of computerised diagnostic programs available to those with video-disc players and home computers. The pharmaceutical company Smith, Kline and French has produced an interactive video-disc to educate doctors in the field of gastro-enterology (The disc however is extremely expensive at £28 000). A number of computer software firms offer for sale computer programs designed to aid doctors in the diagnosis of various psychiatric conditions. (They are known as 'HEADACHE' and FREUD'!). There are also a number of programs available to home-computer owners such as Network Computer Systems' 'First Aid Program' and Eastmead's 100 program 'Home Doctor' series which, claims Eastmead, 'aims to complement the services offered by the NHS by providing patients with a series of simple health programs which differentiate between those symptoms requiring medical attention, emergency and routine, and those which could safely be treated at home without help (*Medical News*, 7 April, 1983).[23]

Self-diagnosing computer programs are thus available but they are not very sophisticated and are certainly not able to recommend very detailed courses of treatment. Nevertheless these various technological developments make the self-service option within health care more possible, subject of course to other economic and political decisions providing both the infrastructure and the incentives for their development as mass market commodities. Of course, it is possible to envisage various *intermediate* stages in any path of development to self-service diagnosis, etc. – the high cost, in the formal health-care system, of continued analysis for some conditions may make self-analysis technologies an economic option within a more cost-conscious health service. Computer-aided diagnostic systems may be best operated by para-medics, screening out patients with routine ailments but under the professional scrutiny of more highly-trained doctors possibly within a private health care system. Vital here will be the attitudes of the medical profession towards what is quite clearly a challenge to their monopoly over medical knowledge (Child *et al.*, 1983). Whatever they do, it is quite conceivable that preventative health programs, of both the computer and video kind, compiled with keep-fit routines and information on

healthier lifestyles could infiltrate the home via the computer, video and cable TV markets.

Whatever are the various paths whereby such equipment will come into routine use outside the existing formal health-care system, it does seem clear that information technologies will change in some fashion the way the population seeks to satisfy its requirements for health care. The questions remain as how, to what extent and for which social groups? Of course, any increase in the informal, self-service sector will depend on the relative costs of the two sectors and this is linked to the policies of the health-care authorities, of the health insurance companies, and of the medical profession.

CONCLUSION

We have tried to show in this chapter how new electronic and telecommunications devices, with the appropriate software of course, can have profound implications for the way in which service production is organised over the next few decades. Indeed, far from the post-industrial scenario of a highly mechanised manufacturing sector supporting a huge, low productivity, labour-intensive sector of service work, information technologies provide one of the means in which the service sector itself can show large rises in productivity. The service sector is the site of major upheavals in the forms of organisation of production in advanced capitalist societies.

In clerical work, self-servicing externalisation and the welfare services, there are two aspects to these upheavals: first, the nature and structure of the services provided, in particular the changing mix of waged service labour, machinery and unpaid self-servicing labour, and second, the labour processes whereby the waged service labour delivers the service product. Information technologies do not of themselves determine the outcome of the struggles, between firms or between workers and managements, over these incipient changes, but they do change the range of options for profit-making in services and thus present new areas and issues over which the struggles can take place. So by making possible the more rapid processing of variable information by means of advanced computers and communication networks, types of service product which required relatively large numbers of experienced information-handling workers can be offered more cheaply.

However, such productivity increases need not be gained by

Fordist organisational methods of job simplification and standardisation within some hierarchical management system. Much more diverse forms of production and work organisation become possible, although we need not assume that the favourite of progressive management consultants – autonomous work-groups integrated by interactive computer networks – is the only one. As we have described, organisationally highly centralised but geographically dispersed forms of production organisation – such as 'tele-outwork' – despite their questionable advantages for the outworkers are equally possible, along with 'satellite' offices, for some types of clerical work at least. It is our contention that whatever organisational forms might be adopted to exploit the potential of information technologies, they will be best understood as marking a discontinuity with Fordist forms of organisation that have previously been devised for some service industries; hence our emphasis on neo-Fordism.

But such reorganisation of service labour processes will imply changes in how the service product is delivered and indeed the nature of the service product itself. The externalisation of service labour, with individual consumers providing at least part of the service themselves, is already established in retailing and mass catering and is likely to expand rapidly into the information services as higher capacity telecommunication infrastructures are installed and domestic terminals and input devices fall in price.

As we have tried to show in our admittedly rather speculative discussion of possible information technology-driven changes in medical diagnosis and health care, information technologies in their application are not just limited to improving the labour productivity of welfare services as presently delivered. Much more substantial changes, satisfying human service functions in radically new ways, are conceivable, although, as we have pointed out, such changes will not inevitably occur just because they can be imagined technologically. Nevertheless it is clear that as new profit opportunities are sought in the current depression, the application of information technologies to service industries is a prime candidate; changes in the modes of service delivery – the switch from labour-intensive service provision to new mixes of computer-based equipment with intermediate services and self-service labour – are at the centre of making information technologies profitable. Any upswing for capitalist economies must be based not just on some restructuring of existing industries but on finding *new industries* in which to make profits.

5

THE END OF MASS PRODUCTION?

K. WILLIAMS, T. CUTLER, J. WILLIAMS & C. HASLAM

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Text reviewed:

Michael Piore and Charles Sabel *The Second Industrial Divide: Possibilities for Prosperity* Basic Books, New York, 1984.

As the economic performance of the advanced Western economies has deteriorated since the early 1970s, so there has been growing interest in the nature, origins and outcome of the present difficulties. Piore and Sabel's book *The Second Industrial Divide* is a contribution to this debate. These two American academics present a distinctive account of what has been increasingly perceived as a 'general crisis of the industrial system' (Piore and Sabel p. 165). Their book ranges widely over many themes but the basic thesis is a simple one; Piore and Sabel argue that 'the present deterioration in economic performance results from the limits of the model of industrial development that is founded on mass production (Piore and Sabel p. 4). As for solutions, Piore and Sabel are agnostic about what will or must happen but they present 'flexible specialisation' as an alternative model of industrial development which offers us the possibility of a prosperous future.

In the United States, *The Second Industrial Divide* was well received and 'flexible specialisation' has been taken up as an idea whose time has come. In Britain the reception has been more mixed. Hyman (1986) has produced a trenchant neo-Marxist critique of the 'myth' of flexible specialisation. But others on the left have reacted quite differently. Murray (1985) has taken up the idea of the obsolescence of mass production with enthusiasm in an article which was provocatively titled 'Benetton Britain'. More significantly, Piore and Sabel's concepts are already being used to provide a framework for further research. A forthcoming

book on the car industry, edited by Tolliday and Zeitlin is boldly titled *Between Fordism and Flexibility*. This reception justifies a review article which summarises and criticises some of Piore and Sabel's main arguments.

Given this objective, our review article is organised in a fairly straight-forward way. It begins by presenting an analytic summary of the *Second Industrial Divide's* main arguments and then moves on to raise a series of critical questions about these arguments. Is it possible to distinguish between mass production and flexible specialisation? Is there a unitary system of mass production which triumphed for reasons which Piore and Sabel identify? Is mass production breaking up? And, finally, how do we regenerate manufacturing and what benefits can be obtained from this regeneration?

Piore and Sabel's argument

The *Second Industrial Divide* is based on a conceptual distinction between two types of industrial production, mass production and flexible specialisation. On the one hand we have 'mass production' which is characterised by 'the use of special purpose (product specific) machines and of semi-skilled workers to product standardized goods (Piore and Sabel p. 4). The more general the goods, the more specialized the machines and the more finely divided the labour that goes into their production (Piore and Sabel, p. 27). On the other hand we have flexible specialisation or craft production which stands in a neat polar opposition to mass production. This type of production is based on skilled workers who produce a variety of customized goods (Piore and Sabel p. 17).

The text builds a large and ambitious superstructure on the basis of this one opposition. The superstructure has three interrelated elements: first, a theory of types of economy, their characteristic problems and how these problems can and have been resolved; second an interpretative meta-history of the development of modern manufacturing since 1800; third, and finally, an analysis of the current crisis of the advanced economies and its possible solutions. Seldom in the history of intellectual endeavour, can so much have been built on the foundation of one opposition. Piore and Sabel's book is best approached by examining the three super structural elements in turn, beginning with the theory of types of economy.

For Piore and Sabel, mass production and flexible specialisation are not only paradigmatic types of production, they can

also be historically realised as types of economy where one kind of production dominates over a given geographic area – regionally, nationally or internationally. Thus the United States from the late nineteenth century created a mass production national economy which was successfully imitated by follower countries in the post–1945 period, thereby creating an international 'mass production economy'; the term itself is used in the title of chapter seven. On a regional basis, viable local economies based on flexible specialisation were realised in nineteenth century European industrial districts, from Lyons to Sheffield, which produced textiles and metal goods. (Piore and Sabel p. 28).

If they repeatedly assert and assume that one type of production can dominate a given area, Piore and Sabel never specify criteria which might be used in deciding whether or not one type of production is dominant in a particular case. When it comes to conceptualising mass production, this issue is of some importance because there is no possibility of a real national economy where all production is undertaken on a mass production basis; as Piore and Sabel concede 'some firms in all industries and almost all firms in some industries continued to apply craft principles of production' (Piore and Sabel p. 20). The survival of something other than mass production is necessary when some end user demands are too small or too irregular to justify mass production and the special purpose machinery required for mass production cannot itself be mass produced (Piore and Sabel. p. 27). In a very orthodox way, Piore and Sabel suppose that the industrial *locus classicus* of modern mass production is in the manufacture of consumer durables (especially cars) and in industries linked to consumer durables such as steel, rubber and plate glass (Piore and Sabel p. 77).

One further complication arises because Piore and Sabel argue that follower countries had, and used, discretionary choice about the organisation of work and methods of labour control and therefore about the degree to which they substituted semi-skilled workers for craftsmen as they introduced mass-production (Piore and Sabel, p. 134). The American mass production system of 'shop floor control over the work process' (Piore and Sabel p. 111) involved narrow job definitions and seniority rights (Piore and Sabel p. 173) in an authoritarian system where management directed the semi-skilled. By way of contrast, countries like West Germany and Japan (Piore and Sabel p. 144, 161) retained important elements of an alternative 'craft system of shop floor control' (Piore and Sabel p. 116) in their factories where management cooperated with multi-skilled workers. In such cases, a mass production national economy can include the labour control elements

of its craft opposite and the distinctiveness of mass production in these cases rests narrowly on part of the basic opposition, namely the use of specialised machines to make standardised goods.

Although the distinction between types of economy is thus blurred the notion of differences is sustained partly through the argument that the two types of economy have characteristically different secular economic problems. In both mass production and flexible specialisation, economic stagnation always threatens to interrupt economic development and often does so. But the causes of stagnation are different in the two types of economy, and the ways in which development can be, and has been, restored are very distinct.

Mass production is represented as not so much an economic state as a technologically dynamic trajectory. As mass production develops, the supplying enterprise can capture economies of scale and realise ever-lower production costs and selling price through investing in new generations of product-specific equipment which turns out even larger volumes of standardised goods (Piore and Sabel pp. 52–4). But if the market will not absorb the output, then the mass producer suffers the high fixed costs of an inflexible production system. Piore and Sabel argue that we have learnt in the twentieth century 'that the product specific use of resources pays off only when market stability is ensured' (Piore and Sabel p. 163). To resolve this problem, mass production economies require regulatory institutions that secure a 'workable match' between the production and consumption of goods (Piore and Sabel p. 4).

Existing institutional arrangements often fail or are inadequate for the purpose of regulation. Where they do fail the result is a 'regulation crisis' as in America in the 1890s or 1930s (Piore and Sabel p. 5). Such crises can only be solved through institutional re-construction and innovation. Thus, the crisis of the 1890s was ended with the development of the large corporations which at a micro level stabilized their individual markets by such tactics as ensuring that the fluctuating component of demand was supplied by small marginal producers. (Piore and Sabel pp. 55–6). While the crisis of the 1930s was resolved after the second world war at a macro level through an assortment of Keynesian novelties. In the United States these included new state initiatives such as welfare expenditure, high levels of arms expenditure and 'private' arrangements like wage bargaining on the 1946 UAW/GM pattern which ensured expansion of demand through tying wage rises simultaneously to productivity increases and the rate of inflation (Piore and Sabel pp. 79–82).

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If the problem of mass production is one of stabilizing the market, the problem of flexible specialisation is one of ensuring that technical dynamism which Piore and Sabel term 'permanent innovation' (Piore and Sabel p. 17). Under flexible specialisation adjustment to the market is not a major problem and macro regulation is not so crucial. This is because flexibly specialised producers employ general purpose equipment (like the Jacquard loom) which enables the enterprise to shift within and between families of products (Piore and Sabel p. 30). But Piore and Sabel argue that systems of flexible production run a high risk of stagnating technologically because variation in product design and process technology can be limited while firms attempt to cut production costs by sweating labour and using inferior materials. (Piore and Sabel p. 263). On this reading of historical experience 'innovation is fostered by removing wages and labour conditions from competition and by establishing an ethos of interdependence among producers in the same market' (Piore and Sabel p. 272). These objectives can be achieved in a variety of ways. In nineteenth century industrial districts, municipalism, paternalism and familialism all provided organising principles for limiting and structuring competition (Piore and Sabel p. 31). But, one way or another, it is presumed that resources can only be mobilised for permanent innovation if the community is involved and there is a fusion of economic activity, or production in the narrow sense, with the larger life of the community.

The theory of types of economy that we have discussed so far is distinct from the meta theory of history which is the second major element in the superstructure that Piore and Sabel erect on the basis of the opposition between flexible specialisation and mass production. It is logically separate because it would be possible to advance a theory of types of economy without developing a meta history. The meta history of manufacturing which Piore and Sabel present is a variant on the stages theories of economic growth and modernisation which were popular in the 1960s. If this kind of meta history is now being revived by Piore and Sabel, it is being revived in a variant form. The notion of unilinear progress to modernity is rejected as is the notion of a single divide which separates the traditional 'before' from the modern 'after'. That much is signalled by Piore and Sabel's title 'the second industrial divide'.

The meta history of Piore and Sabel is built on the assumption that mass production and flexible specialisation are not only concepts but empirical forms which persist and recur throughout the modern period. Although technology changes and techniques of micro and macro regulations develop, the empirical forms retain

the same identity in the 1800s or the 1980s. Thus Piore and Sabel can claim that 'throughout the nineteenth century two forms of technological development were in collision' (Piore and Sabel p. 19). Equally, there is nothing new about the kinds of flexible specialisation which are being developed in the 1980s. Piore and Sabel repeatedly claim that the spread of flexible specialisation now amounts to a revival or 'return to craft methods of production regarded since the nineteenth century as marginal' (Piore and Sabel, p. 252; see also pp. 6, 17). On this view, history must be a process which permutates the two empirical forms which are always the same.

As Piore and Sabel set it up there are only rare moments of choice 'when the path of technological development is at issue' (Piore and Sabel, p. 5) and at which societies can choose between a future built on one or other of the two forms. These moments of technological choice are termed 'industrial divides' and Piore and Sabel identify two of them. The first occurred 'in the nineteenth century' when the emergence of mass production technology – initially in Great Britain and then in the United States – limited the growth of less rigid manufacturing technologies which existed primarily in various regions of Western Europe (Piore and Sabel, p. 5). The second industrial divide is contemporary and dates from the stagnation of the international economic system in the 1970s which is still continuing in the 1980s. Although the two 'divides' are separated in time, the choice is necessarily the same in both cases; it can only be between mass production and flexible specialisation.

This schematic meta history is buttressed with arguments about how and why social choice of technological development occurs rarely and with an account of the determinants of that choice. Crises are not unusual in mass production economies. But most of these crises are 'regulation crises' about the institutions which connect production and consumption rather than 'industrial divides' where the technological form of development is at issue. (Piore and Sabel, p. 5). A kind of inertia holds manufacturing economies onto one 'trajectory' after the choice of technology has been made. As Piore and Sabel argue 'technological choices, once made, entail large investments in equipment and know how, whose amortization discourages subsequent different choices' (Piore and Sabel, p. 38). After an industrial divide one of the contending forms of production wins out and 'the tendency towards uniformity is reversed only when some combination of developments in the market and in the capacity to control nature makes it economically feasible to strike out in new directions' (Piore and Sabel, p. 39).

When it comes to conceptualising the determinants of choice at each divide, Piore and Sabel quite reasonably want to deny any iron law of historical necessity and more specifically to avoid the kind of technological or market determinism which the last quotation hints at. Thus, they reject what they call the classical view which attributes the triumph of mass production in the twentieth century to lower production and selling costs. No examples of cost differentials between craft and mass production are presented but throughout the text it is assumed that at the first and second divides flexible specialisation was, and now is, an economically viable and efficient alternative to mass production. On Piore and Sabel's account, the outcome at a divide is settled by the exercise of political power and the commitment of financial resources. 'The technical possibilities that are realised depend on the distribution of power and wealth: those who control the resources and returns from investment choose from among the available technologies the one most favourable to *their* interests' (Piore and Sabel, p. 38, emphasis in original). What follows is that mass production did not succeed because of its superior economic efficiency in prevailing conditions but rather due to the resources thrown behind those engaged in promoting and using mass production techniques.

Piore and Sabel's anti-classical theory of technological choice is garnished with a rhetorical contrast between the reality of openness at each divide and the ideological appearance of closure after the divide. Piore and Sabel imply that the choice could have gone the other way at the first divide and could now go either way at the second divide. We live in 'a world in which technology can develop in various ways; a world that might have turned out differently from the way it did, and thus a world with a history of abandoned but viable alternatives to what exists' (Piore and Sabel, p. 38). They thus offer a 'branching tree view of history' (Piore and Sabel, p. 67) and claim that the limbs of this tree 'thrive or wither according to the outcomes of social struggles, not some natural law of growth' (Piore and Sabel, p. 15). This openness is ideologically obscured after each industrial divide by the triumph of a 'technological paradigm' which presents the newly dominant form of production as the natural and inevitable victor. Piore and Sabel here borrow the concept of paradigm which Kuhn applied to scientific theory and apply it to a 'vision of efficient production'. They claim ' a new technological paradigm . . . creates the conditions for a new orthodoxy . . . at best half aware that their imagination has been circumscribed by convention, technologists push down the new path' (Piore and Sabel, p. 44). When the paradigm operates to confirm certain techniques and excludes

others, the triumph of mass production in the twentieth century is a result both of material support and ideological effect.

The meta history outlined above does not completely determine their position on the current 'general crisis of the industrial system' (Piore and Sabel, p. 165). Piore and Sabel's position on these issues can therefore be considered a third element in the superstructure which they build on top of the basic opposition between mass production and flexible specialisation. But the identification of the crisis at a meta historical 'second industrial divide' does influence their treatment of the crisis which is self-consciously 'open' about causes and outcomes. Thus Piore and Sabel present two supposedly 'alternative' accounts of the origins of the crisis which is caused either by external shocks or internal structural problems in the mass production economies. Equally, they maintain the crisis could be resolved with the victory of either flexible specialisation or a revived Keynesianism. Our authors are avowedly neutral; either of the two causal accounts might be correct and both outcomes are possible (Piore and Sabel, pp. 166, 251). But on our reading, this neutrality is a decorous pretence. The two 'alternative' explanations are largely complementary insofar as the external shocks exacerbate the structural difficulties which advanced economies are beset by. While, in terms of outcome, there can be no real alternative to flexible specialisation because their preconditions for a regeneration of Keynesianism cannot be met.

The first account of the causes of the present crisis presents it as an 'accident' caused by external shocks such as the oil price rises of 1973 and 1979 or the breakdown of the post-war regime of fixed exchange rates, (Piore and Sabel, pp. 66–82). These shocks generated uncertainty; the viability of products and processes depended, for example, on the unpredictable future level of oil prices. Such uncertainty inhibits investment and thus has a depressing effect. In the second account what we have is a kind of internal structural crisis of mass production where the problem is the level and composition of demand nationally and internationally (Piore and Sabel, pp. 183–93). On this structural account the problem is 'the saturation of core markets' and 'the break up of mass markets for standardized products'. The structural explanation is complementary because the internal problems inhibit investment just like the external shocks. Thus confusion about the level and composition of demand had the effect of 'reducing the portion of demand that employers saw as sufficiently long term to justify the long-term fixed cost investments of mass production' (Piore and Sabel, p. 83).

The immediate market problem is 'saturation of industrial

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markets in the advanced economies' (Piore and Sabel, p. 187). The argument here is focused on the market for long-established consumer durables such as cars and washing machines; 'by the 1960s domestic consumption of the goods that had led the post-war expansion began to reach its limits' (Piore and Sabel, p. 184). This was a problem because 'no new products emerged to stimulate demand for mass produced goods' (Piore and Sabel, p. 189); specifically computers and home entertainment never became mass production industries. The other market problem for the mass producers was the 'break up of mass markets for standardized goods' (Piore and Sabel, p. 183) in a world of increasing product differentiation on the supply side and growing diversity of tastes on the demand side. The effect of mass market saturation and break up in the advanced countries was accelerated by the development strategies of many third world countries. The protectionist Latin American countries closed off their internal markets while the Asian NICs aggravated market congestion in the advanced countries by pursuing strategies of export led growth. (Piore and Sabel, p. 189).

If these are the dominant market trends, they constitute a problem for mass production and an opportunity for flexible specialisation which operates with multi-use low cost capital equipment. Current trends in manufacturing technology, particularly the development of computer controlled equipment, reinforce the advantage of flexible specialisation in meeting such demand. Piore and Sabel maintain that flexible specialisation is dynamic 'independent of any particular state of technology' and recognise that computers can be put to rigid use by mass producing enterprises. But potentially computer control of equipment like machine tools offers major advantages to flexibly specialised firms producing the small batches and short runs which a differentiated market requires. It is not necessary to replace the machines as in mass production or to manually change tools and fixtures as in old fashioned flexible specialisation; with computer technology, the equipment can be put to new uses without physical adjustment 'simply by re-programming' (Piore and Sabel, p. 260). Piore and Sabel's discussion of new technology concludes with a paean of praise for the computer as the contemporary equivalent of the nineteenth century artisan's tool which now has the liberating potential to ease the tyranny of specialized machinery over semi and unskilled workers; 'the advent of the computer restores human control over the production process, machinery is again subordinated to the operator' (Piore and Sabel, p. 261).

Despite all this, Piore and Sabel formally insist that Keynesian-

ism might be revived and markets could be stabilised so that mass production might provide a basis for renewed prosperity on the other side of the present industrial divide. But a new form of 'international Keynesianism' would require large changes which, according to Piore and Sabel, can only be initiated by national governments acting together. If Keynesianism is to make the world safe for mass production, their prerequisite is new global regulatory mechanisms which raise purchasing power in at least some of the less developed countries. Positively, for example, there must be arrangements which ensure that demand expands at a rate equal to the expansion of productive capacity and mechanisms which apportion the expansion of productive capacity between advanced and developing countries (Piore and Sabel, pp. 252–7). No doubt the IMF could act more expansively and perhaps currency exchange rates could be managed. But when the European countries cannot agree on co-ordinated reflation, it is incredible that the United States, Europe and some of the less developed countries could agree on the much more far-reaching changes which Piore and Sabel insist are necessary.

Against this background of a supposed internal blockage of mass production, Piore and Sabel are able to find regional islands of prosperity built on flexible specialisation which has already 'challenged mass production as the paradigm' (Piore and Sabel, p. 207). Industrial districts like Prato or Emilio Romagna in Central and North Western Italy provide a model for our future (Piore and Sabel, p. 206). The challenge now is 'to see how flexibility – until now confined to a relatively small segment within the mass production system – can be extended throughout the economy' (Piore and Sabel, p. 258). These national developments are likely to produce a new international division of labour. As mass production economies of scale become irrelevant 'the more likely each nation would be to produce a wide range of products on its own' (Piore and Sabel, p. 277). Elsewhere Piore and Sabel envisage that mass production will migrate to the LDCs while the advanced countries specialise in high tech, footwear, garments and machine tools.

Making distinctions

It is now time to turn from exposition to criticism and our criticism begins by considering the basic opposition between two types of production; mass production relying on special purpose product-specific equipment and semi-skilled workers to produce standardized goods versus flexible equipment and skilled workers to produce customized goods. Does this opposition provide a secure

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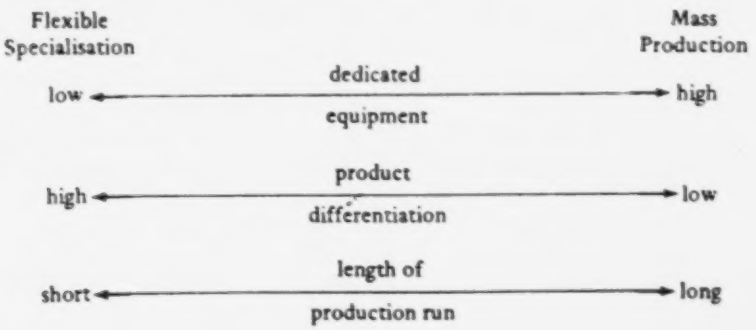
foundation for a large superstructure of meta history? Our answer is that the opposition is not up to the job. Piore and Sabel never develop criteria for indentifying instances of mass production and flexible specialisation in a way that is intellectually satisfactory. The identifications that Piore and Sabel do make are in our view, arbitrary and unjustified.

This issue has already been raised in our exposition. We noted then that Piore and Sabel fail to state criteria of dominance which would allow us to determine whether and when one form of production comes to dominate a given area thereby creating a distinctive regional or national economy of the mass production or flexible specialisation type. Worse still, our argument below shows that it is very difficult to identify particular enterprises or industries as instances of mass production or flexible specialisation. At a conceptual level, the opposition appears clear cut. When there are national differences about the organisation of the labour process, there are only three invariant dimensions of difference between mass production and flexible specialisation. These differences concern the dedication of equipment, the extent of product differentiation and the length of production runs. They are summarised in our diagram below:



The problem of identification arises because, in most instances, a specific enterprise or industry cannot be neatly situated at one pole of variation (on the far left or right in the diagram) in all three dimensions. It is certain, for example, that many enterprises and industries which Piore and Sabel would classify as mass production do not use completely dedicated equipment to produce a single standardized product. The car industry provides some obvious illustrations of this point.

Many significant items of equipment in car factories are not dedicated. Consider, for example, the large hydraulic presses which have been used for more than fifty years in car factories

to produce steel body panels. Such presses have a working life of approximately thirty years and a high rate of throughput (Hartley, 1981, p. 29). A modern car firm would not keep one model in continuous production for the life of the press and, at any one moment in time, the press will be used to produce a variety of panels for one or more models. Different panels are obtained by changing dies and the press is simply equipped with a new set of dies when models are changed over. As so often in the production of consumer goods, the tooling is dedicated and model specific but many items of capital equipment are re-usable. Does that make the car industry less of a mass production industry or not a mass production industry?

As for product differentiation, the output of major firms does not usually consist of a single standardized product which stays in production for decades. The Ford T and the Volkswagen Beetle are exceptions. Other car producers have increasingly imitated the General Motors strategy of providing a range of differently priced models. And, in the European car business, differences in size have always been important. This kind of mass production differentiation is disparaged by Piore and Sabel who observe that GM's models shared many components and were only 'presented as different' (Piore and Sabel, p. 51). But that disparagement is unjustified when Piore and Sabel provide no criteria for discriminating between fundamental difference and trivial styling variation which they admit is commonplace in both flexible specialisation and mass production.

The conclusion must be that dedicated equipment and limited product variety are not unproblematic characteristics which can be used to differentiate the mass production enterprises and industries from the rest. In this case, does length of production run provide an empirical yardstick which can be used to identify mass production and corroborate the meta history? It would, for example, be significant if Piore and Sabel were able to present statistical evidence which showed that, in the consumer durables industries, production runs had grown dramatically shorter over the past fifteen years. But in a three hundred page book, there is no statistical evidence at all on production runs for *any* product of the nineteenth or twentieth centuries. Even if evidence were to be supplied, that would of course raise a whole series of questions about how short a production run has to be before we cross the rubicon from mass production to flexible specialisation? This key question is not posed or answered in *The Second Industrial Divide*, where the deficiencies of the argument are covered up by a regression into circular argument and self reference. If we ask how long is the production run of a mass produced piece of

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string, Piore and Sabel's answer would be that the production run of craft string is shorter.

If each dimension of difference between mass production and flexible specialisation turns out to be problematic, the difficulties of identification are compounded if we consider the way in which the dimensions of difference are articulated together. As our diagram shows, the simple Piore and Sabel opposition presupposes a particular pattern of joint variation in all three dimensions of difference. A (every?) mass production enterprise will combine limited product differentiation and long run production runs. But it is fairly easy to show that at an enterprise level some 'mass producers' of differentiated goods can sustain long runs while others do not. Japanese majors in consumer electronics can achieve long runs because they have a high share of a protected home market and export successfully to the rest of the world. Thus in the late 1970s, cumulative volume per tv chassis type was 1.2 million in Japan, compared with an average of 400,000 in Europe and just 150,000 in the UK whose national producers did not export and were losing share of their home market (Magaziner and Hout, 1980). In this instance, differences in the size of the available market determined massive differences in production run for enterprises producing similarly differentiated products.

Nor can the existence of a wide range of choice be used to identify an area where flexible specialisation is necessarily making ground. Under free trade conditions, mass production now invariably provides a bewildering choice; British consumers can choose between more than thirty brands and around twenty different makes of washing machines from British and European factories (*Which*, 1986). If that choice does not amount to very much then that is because one product type (the front loader) dominates the European, washing machine market.

The implication of our argument is that mass production and flexible specialisation connot be satisfactorily identified in particular instances, even at the enterprise and industry level. This weakness must undermine much of Piore and Sabel's argument that mass production did displace flexible specialisation in the nineteenth century and that flexible specialisation can now displace mass production. After all if we cannot identify instances of mass production or flexible specialisation how can we determine that one type of production is displacing the other?

Challenging the meta history – the case of Ford

The general problem with meta-history is that it tries to stuff too much into the same bag. This is inevitable when any long and com-

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past historical experience is summarised with the aid of a simple framework which identifies only a couple of stages or divides. This produces certain characteristic effects. some processes and episodes will be misrepresented because the interpretative presuppositions of the framework have to be satisfied. While other processes and episodes will vanish because they cannot be handled within the framework. When Piore and Sabel are so economical with the concepts and assertive about the connections, it would be surprising if they avoided these problems in their meta-history of manufacturing since 1800. And the issues here are best approached by examining the crucial case of Henry Ford and the Model T. If we except a rather curious attempt to represent the 5$ day as a primitive policy for boosting demand, what Piore and Sabel say about Ford is fairly orthodox. Thus, they note two points which are emphasised in the existing secondary literature: first, Ford's process innovations lowered the price of his product and thus extended the market (Piore and Sabel, p. 51): second, Ford was able to finance his company's expansion without public sales of equity and bank loans (Piore and Sabel, p. 70). What they do not pause to consider is that these points raise fundamental questions about whether the Ford case contradicts their meta history and, more specifically, their grand theory of technical change. In our view it does so and this is the theme which we now wish to develop by counterposing Ford's achievement and Piore and Sabel's meta history.

It is necessary to begin by clarifying the issues. We would not wish to argue, following Chandler (1964), that the triumph of mass production was an inevitable response to the potential mass market which the railways created in the United States. Fords success with the Model T depended on a variety of technical prerequisites including product innovations like the robust and easy to use gear change of the T. Nor would we wish to argue that Ford's process innovations had any 'unique' or 'intrinsic' superiority in all circumstances (see, e.g. Piore and Sabel, p. 40). The Ford T succeeded in particular circumstances when the preconditions for a mass market had been established. This point is proved by the sales success of the T in its early years before the most important process innovations had been introduced. Sales increased ten fold to $42.5 million in the years 1908 to 1912 (Nevins, 1954, p. 645; Hounshell, 1984). The question is why mass production triumphed over craft production in these particular circumstances. Piore and Sabel's general theory of technical change asserts that choice of productive technology is settled by the exercise of political and financial power and that seems to imply that the balance of economic advantage is fairly even.

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Ford made radical process innovations in the 1912–3 period by combining technical elements which already existed and applying them to the mass production of a complex consumer good including numerous components and sub-assemblies. There were three key technical elements. The first element was the use of interchangeable parts which had already been pioneered in car manufacture by Cadillac (Nevins, 1954, p. 371). This directly reduced the labour requirement and was a prerequisite for the development of the assembly line. The second key element was the layout of machines in shops according to the sequence of process operations. As a Ford engineer argued, this again reduced labour requirement by eliminating unnecessary internal movement of parts and work in progress (Bornholdt, 1913, p. 277). The third and final element was the introduction of the moving assembly line which had originally been applied to the stripping of carcasses in the meat trade. When applied to the key operation of assembling the chassis of a light touring car, the results were dramatic. In August 1913, 12.5 man hours went into assembling the Model T chassis; by April 1914, after the assembling line had been introduced, the labour requirement was reduced to 1.5 man hours. (Arnold and Faurote, 1972, pp. 136–9).

All this required an increase in capital investment, but the reductions in labour input were so large that Ford dramatically reduced costs of production. The benefit was passed on to the consumer in the form of lower selling prices, as table 1 shows.

The Ford T was a keenly priced, bottom of the market motor car

Table 1 Selling price of the Model T touring car

	$
1908	850
1909	950
1910	780
1911	690
1912	600
1913	550
1914	490
1915	440
1916	360

Source: Nevins (1954

when it was introduced in 1908. But, by 1916, in real terms allowing for inflation, the price had been quartered. This was not at the expense of Ford Motor Company's profits which increased from $3 million in 1909 to $57 million in 1916 (Nevins, 1954, p. 647).

One further crucial point is that the success of the Ford Motor Company was not politically sponsored or supported by financial institutions. Of the $100,000 initial capital over half was credited to Ford and Malcolmson for machinery and patents, only $28,000 was paid in cash. The eleven original backers who put in money were small businessmen, a brace of lawyers, a carpenter and an office worker (Nevins, 1954, pp. 236–7). These men were not Rockefellers and they did not have a direct line to John Pierpoint Morgan. Equally, none of Ford's backers would have been persona grata at meetings of the executive committee of the bourgeoisie. The inescapable conclusion is that political and financial sponsorship was unnecessary because, in the particular circumstances of the time, Ford's combination of process innovations had an overwhelming economic advantage over the 'craft methods' of production which had been used hitherto to make cars which were toys for rich men.

All the rhetoric about 'branching trees' and openness covers one central deficiency in Piore and Sabel's account of mass production versus flexible specialisation at the first divide; they never present any evidence on the cost of producing cars, or any other complex durable, by alternative methods. The case of the Ford T suggests there never was a choice because there was not a viable craft alternative to mass production of complex consumer durables. That explains why Piore and Sabel are unable to cite any examples of successfully surviving craft production in the key industrial areas where mass production developed. In industries like cars, craft producers only survived precariously by moving up market and meeting the small scale demand for high priced luxury alternatives to mass produced manufacturers.

Challenging the meta history – mass production after Ford

The case of Ford and the T shows how our meta historians can ignore crucial cases which contradict their meta history. We now wish to turn to make the rather different point that Piore and Sabel's account of subsequent mass production fails to register distinctions and differences which are important but do not exist within their framework. In their meta history mass production is always the same and the inevitable outcome, after the triumph of mass production, is a history where nothing really happens except for 'regulation crises'. In an earlier text, Sabel accepted the

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logic of that position and proposed the concept of 'Fordism' as a kind of shorthand for mass production; 'I will use Fordism as a shorthand term for the organisational and technological principles characteristic of the modern large scale factory' (Sabel, 1983, p. 32). When adequate criteria of instances are never elaborated, it becomes possible to see Fordism everwhere in manufacturing over the past sixty years. Against this we wish to argue that Ford's innovation of the assembly line factory had a limited field of application and Ford did not provide a strategic model which his successors imitated. Ford's production techniques only had an overwhelming cost advantage in the production of complex consumer durables, initially cars and electrical goods, and subsequently in the field of electronics where the products included consumer and producer goods. That gave mass production a substantial field of application; in a recent survey of British manufacturing, 13 per cent of the plants in the sample produced products which contained more than 1,000 components (New and Myers, 1986, p. 6). But for simpler consumer goods, like clothing and furniture, mass production techniques had a limited advantage. Meanwhile the capital intensive process industries, like steel and chemicals, went their own way before and after Ford. It is therefore quite understandable that most plants in the advanced economies do not contain assembly lines; the survey of British manufacturing which we have already cited shows that 31 per cent of plants in the sample used assembly lines and only half of those were mechanically paced (New and Myers, p. 31). Ford's innovations may have been important but they are hardly responsible for the whole trajectory of development in the advanced economies. Rather they created what Mitsui aptly calls assembly industries. Even within this field, Ford did not provide a model which his successors imitated and for that reason alone the concept of 'Fordism' is seriously misleading. As we have already noted, Ford's successors did not generally imitate his product strategy of relying on one long lived model. Most assemblers succeed by making families of inter-related models which are changed over fairly regularly. Equally important, Ford's successors did not aspire to become fully integrated producers who carried out all the operations necessary to production in their own factory. The 'classic' integrated Ford plants of the 1920s and 1930s like Highland Park, Dagenham and Cologne are not typical mass production factories. Ford's successors ran assembly factories whose internal process operations were fed with bought out components. In most European car factories since 1945, bought out components account for half the cost of the finished motor car. These crucial variations on 'Fordism' had important repercussions for the composition of

assembly output and for the organisation of production in the assembly industries

After Ford, assembly was associated with volume and variety at the enterprise level. This was technically possible because assembly lines can be run productively and profitably at relatively low model volume. That point was demonstrated by the way in which Austin and Morris were able to adopt Ford's innovations and achieve significant cost reductions when supplying the relatively small British market for cars in the 1920s and 1930s. Much of the history of mass production in Europe between the wars was one of the adaptation of mass production to lower volume. The next major turning point came after the early 1960s with Japanese innovations in cars and electronics. This showed how the objective of greater variety could be achieved by mass production enterprises which also chased volume increases. Enterprises like Toyota have developed the use of 'mixed lines' where two or more models are assembled on the one line, pressed through inventory reduction through the Kanban system and 'just in time' parts delivery, and also dramatically reduced change over and set up times on equipment like power presses (Shonberger, 1982). The Japanese have demonstrated that productive and marketing advantage can be obtained cheaply because assembly line factories can be used much more flexibly than in most Western countries.

As for the organisation of production, the assembly industries created opportunities for large, medium and small scale enterprises which can be connected in a variety of different ways in input – output terms. Piore and Sabel's treatment of these issues is confused and confusing. They distance themselves from 'the popular view that increasingly associated large plants with mass production' (Piore and Sabel). But they generally treat the survival of something other than large scale production in the mass production industries as evidence of the deficiency of mass production and relate the survival of small firms in that sector simply to the requirements of Fordist firms for specialized equipment to build their standardised products. Against this, we would argue that it is the requirement for components which creates the main market opportunities for small firms. These opportunities are substantial, even in the case of sophisticated products like VCR's where the assembler naturally monpolises the technically difficult high volume process work of head production (Mitsui, 1986). Small or medium firms can also prosper in final assembly if component semi-manufacturers are being produced in volume by large scale enterprises. This is one pattern in areas of electronics where there is large scale production of commodity semi manufacturers like tv tubes, transformers and silicon chips. One of the more

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eccentric aspects of Piore and Sabel's book is that they effectively identify mass production with the production of final products for the consumer.

The discussion so far has emphasised some of the differences and distinctions which Piore and Sabel neglect. The concept of Fordism should clearly be rejected because it elides too many differences and establishes an uninformative stereotype. Furthermore, any notion of a generic modern system of mass production should be treated with great caution because there are many different ways of organising production, even in the assembly industries. It would be intellectually interesting to analyse these differences. But, until that analysis is provided, it would be foolish to produce substantive work where mass production is a central organising concept.

If the criticism so far has focused on differences and distinctions which Piore and Sabel neglect, it is appropriate finally to examine the one difference which they do recgnise. Culturally and historically determined differences in labour control figure in *The Second Industrial Divide* as the main explanation of variation in the national experience of mass production (Piore and Sabel, p. 162–4). This position rests on a misunderstanding about the general importance of labour in the production process.

As we have argued elsewhere (Williams *et al.*, 1987), labour control is a managerial obsession which attracts attention in a way which is disproportionate to its real significance. If Piore and Sabel accept managerial pre-occupations too readily that is because they believe that 'wages are the major component of costs' (Piore and Sabel, p. 84). But modern manufacture since the industrial revolution has been a system which takes labour out; more specifically, Ford and his successors were successful insofar as they took labour costs out without incurring anything like the same capital costs. If that yields a micro economic advantage, it is also crucial to the macro economic process of economic growth which is all about product output growing faster than production inputs, especially labour. One measure of the proportion of total costs in manufacturing, inside or outside the 'mass production' industries (the New and Myers survey of British manufacturing plants which we have already cited) shows that in their sample, direct labour accounted for an average of just 18 per cent of total production costs (New and Myers, 1986, p. 7). What's done tactically with the labourers who remain is much less important than what is done strategically about taking labour out. Although tactical decisions contribute to, they do not determine the strategic outcome which depends on decision about such matters as investment strategy and market-

ing. As we have argued in the case of Austin Rover, no amount of variety of labour control can produce viability if management makes major mistakes about investment and marketing, (Williams *et al.*, 1987). Much the same point could be made about the defeat of Ford and the Model T in the American car market of the 1920s. Labour control was irrelevant because Ford could never win with the T when the market increasingly preferred closed cars, and second-hands supplied the basic transport market.

Mass production is presented by Piore and Sabel as a form of production with a technological-cum-market core plus a variable institutional armature. However the main emphasis then falls on labour control which is the one national difference which Piore and Sabel consolidate into their scheme. We have already argued that this variable cannot explain much and we would finally add that other variables can explain more. If the aim is to explain differences in manufacturing performance, it would be more instructive to examine the role of the stock exchange or the lending criteria applied by different national banking systems. We have shown elsewhere (William *et al.*, 1983) how both conditions influence the performance of British manufacturing. If Piore and Sabel represent a variant of institutionalism, this is an impoverished institutionalism with little explanatory power.

Are mass markets breaking up?

Piore and Sabel argue that mass production has reached its limits when the markets for mass produced goods are saturated and breaking up because consumers are now demanding more differentiated goods. If the level and composition of demand necessary for mass production cannot be restored, in Piore and Sabel's framework we are at a 'second industrial divide' and the only way forward is through a revival of flexible specialisation which was marginalised at the first divide. This section of our criticism will examine the *Second Industrial Divide's* interpretations of current market trends. Our conclusion is that Piore and Sabel's account of the market arises out of conceptual confusion and does not rest on any hard evidence.

Piore and Sabel's argument about saturation is focused on the older consumer durables (cars, washing machines, refrigerators) which are mature products with high levels of market penetration. But that does not in every case prevent substantial growth in volume and value of sales. The market for colour tv sets in Britain has more than doubled in size to 3.7 million sets over the past ten years because households now buy small screen tv's as second sets (BREMA *Yearbook*, 1985). Value of sales is buoyant when three

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quarters of a million teletext sets were sold in 1985 and satellite dishes and high definition tv are just around the corner (BREMA *Yearbook* 1985). TV shows that the most boringly mature product can be re-invented and repackaged to win extra volume and value. In other areas, where the identity of the product is more stable, volume increases are hard to find because market penetration is high. But, for exactly that reason, a huge replacement demand exists. In white goods, for example, 12 million washing machines and 15 million domestic refrigerators are sold in Europe each year. In the new car market, the dominance of replacement demand is associated with cyclical fluctuation as consumers bring forward or postpone their purchase; in most white goods and brown goods the pattern is quite different because replacement demand is extremely stable.

Replacement demand for mature products is not enough for Piore and Sabel who assume that volume increases are necessary for mass producers who seek to move down a long run average cost curve by realizing ever greater economies of scale at higher levels of output. (Piore and Sabel, p. 52). This is formulated by means of a schematic diagram and it is all very hypothetical because a great deal of empirical evidence suggests that the average costs of large firms are often constant over large ranges of output. Even if cost reductions can, in principle, be obtained as output increases, expansion is a risky strategy because it involves fixed investment in capacity increases which will only be profitable if the enterprise and the industry correctly predict the increased size of the future market. There is no good reason why enterprises and industries should not make steady and less risky profits by meeting a large and stable replacement demand which does not tempt producers to invest in over-capacity. If mass production existed, it could be a stable state rather than a trajectory.

In any case if enterprises in consumer goods want increases in volume and value, they can always obtain them by introducing new products, It is salutary here to list some of the new durables which are now being sold in volume in Britain although they did not exist as mass market products ten years ago. In brown and white goods the list would include video cassette recorders, new format cassette players like the 'walkman', compact disc players, micro-wave ovens, dishwashers and food processors. Most of these new products are complementary from the producer's point of view; they can be put together on new lines in existing factories and are sold through existing distribution channels The development of new products by existing producers is completely ignored by Piore and Sabel On the issue of new products, Piore and

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Sabel's one argument is that computers and home entertainment have failed to become mass production industries because their products are insufficiently universal (Piore and Sabel, pp. 204–5). These industries do not produce something like the T which is 'a machine for everyone and everything' (Piore and Sabel, p. 202). This nonsense is the bizarre result of projecting the shadow of Ford onto the reality of modern industry. VCRs are the products of large scale Japanese assembly factories and are sold in mass markets around the world, even if they are not universal audio-visual pleasure machines like Woody Allen's 'orgasmotron'. Indeed, it is not clear why Piore and Sabel do not follow the logic of their own argument and decide that the T was not a true mass market product because Ford failed to produce a 'travel centre' which was capable of flying and crossing water as well as travelling on and off road.

Even if the mass market is not saturated, it is still conceivable that mass markets are breaking up because consumers demand more differentiated products. With the Piore and Sabel framework, market break up is a much more significant development than market saturation. A problem about a saturated market would in itself only create a 'regulation crisis' of the kind which mass production has solved before through reconstructing the institutions which secure a workable match between supply and demand. But problems about market break up would create a much more fundamental kind of crisis and an industrial divide if markets were breaking up in a way which creates patterns of demand which mass production cannot cope with. The argument of the next couple of paragraphs is that markets may be breaking up, but not in a way which is really threatening.

The orthodox mass producer survives by producing a family of inter-related models. And in the case of the major durables it is unusual for consumers to demand more than a handful of product types. In the case of cars in the European market demand has converged onto four distinct product types. The demand is for small, light, medium and large cars which Ford of Europe meets with the Fiesta, Escort, Sierra and Granada. In every major European national market, except West Germany, 80 per cent plus of sales are taken in the three lower classes where the major manufacturers have similarly packaged look alike models. Volume car firms can no longer survive by making one or two utility models as some did in the 1950s and 1960s, but four basic models is all that is required for the current European car market. Variants like 'hot hatchbacks' or coupes can be easily produced by feeding different components onto the main lines or by setting up lines for 'new models' which simply package components from the enterprise

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parts bin in a slightly different way. Such competition only threatens those manufacturers who cannot find volume sales and decent runs and thereby cover development costs.

Length of production run will depend on how the enterprise is advantaged or disadvantaged by the parallel process of market fragmentation which has occurred generally in the consumer goods markets of all advanced countries (except Japan) over the past twenty years. With the increasing interchange of manufactures over this period, the area of trade has widened in most product lines and the number of brands and models represented in any one market increases. As the importers move in, they claim volume and the domestic producer (or producers) with market leadership lose market share. In the British case this has been the fate of Austin Rover or of Hoover, Hotpoint and Murphy Richards who had a dominant position in the supply of many kitchen durables in the 1960s. The British problem is that in many product lines, producers have failed to compensate for the inevitable loss of home sales with a sufficiently large expansion of exports. That explains why Austin Rover which is pinned down on its home market is currently making less than 150,000 units each year of the Metro which is its best selling car. Most mainland European producers in cars or white goods also lost out at home, but market fragmentation was not an insuperable problem for them because they won back volume with increased sales to near European markets. Volkswagen for example, prospers with less than 30 per cent of the German market because it takes 5 per cent or more of every other major national market. On this basis, VW makes more than 800,000 units of its best selling model the Golf each year. In any process of market fragmentation there will be trade winners and losers; enterprises or national industries which lose will be marginalised and possibly forced out of business. But that process does not threaten the system of large scale production, any more than the fact of bankruptcy threatens capitalism.

If Piore and Sabel believe mass markets are breaking up that is because they are conceptually confused about what is going on and crucially fail to draw the distinction between simple product differentiation and market fragmentation which has quite different consequences. Equally clearly their position on 'the break up of mass markets for standardized products' (Piore and Sabel, p. 18) does not rest on any sound empirical basis; as we have already noted they provide no statistics on length of production runs and no criteria for discriminating genuinely different products. There is one empirical test of their position on market crisis. It is asserted that difficulties about the market are reflected in a reluctance to

undertake fixed investment. In a discussion of the shocks of the 1970s, Piore and Sabel claim that such shocks 'reduced the portion of demand that employers saw as sufficiently long run to justify the long term fixed capital investment of mass production' (Piore and Sabel, p. 183). No statistics are cited to support this claim about inhibited investment. The available evidence on capital formation shows that, if this effect operated in the mass production sector, it was not sufficiently strong to depress the level of gross fixed capital formation in all advanced countries.

As table 2 shows, the real manufacturing investment levels of 1970 were effectively maintained or surpassed in 1983 in four of the six national economies. Two economies, West Germany and Britain, show a sustained fall in real investment levels. If the German record is anomalous, the decline in British manufacturing investment can be fairly easily explained when this country was a trade loser which suffered progressive deindustrialisation. The evidence of healthy investment elsewhere is not explained by, but is broadly consonant with, the evidence which we have presented on market opportunities in the assembly industries of cars and consumer electronics. Piore and

Table 2 Gross fixed capital formation in manufacturing (constant prices)

	1970	1975	1983
USA	100	117,3	134,8
UK	100	84,1	57,7
Japan	100	101,6	181,7 (1)
W. Germany	100	59,1	80,3 (2)
France	100	103,7	128,6 (3)
Italy	100	91,1	96,0

Notes

1 West German figure is for year 1982.
2 All French totals include mining and quarrying as well as electricity and gas.
3 Italian figure is for year 1981. All Italian totals include mining and quarrying.

Source: United Nations Annual Accounts.

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Sabel's intimations about market led collapse in these industries appear to be exaggerated melodrama.

The message of new technology

Even if Piore and Sabel are wrong about market demand, they may be correct about the potential of new technology which, on their account, facilitates the resurgence of flexible specialisation. They argue that dedicated equipment and inflexible automation is being superceded by a new generation of micro-electronically controlled machines which allow efficient production in smaller batches. Piore and Sabel take a very definite position on the capability and salience of computer control, but here again they present no solid evidence. Crucially, their book never examines the costs and output potential of specific items of new technology in particular industrial contexts. To redress this absence, we will present some evidence of our own. In modern manufacturing, enterprises are increasingly buying computer integrated manufacturing systems. And we will analyse two cases of such systems; robotised body building lines which are used in the car industry and 'flexible manufacturing systems' (FMS) which are usually used for metal machining. With robots the issue is how new technology changes conditions of production in an industry which has been a central redoubt of volume production in long runs. FMS are more usually installed by capital goods producers and the question here is how new technology changes the economics of batch production.

Commentators like Altshuler (1984, p. 12) and Jones (1985) have recently argued that a new productive flexibility is transforming the economics of the cars business (see also, Piore and Sabel, p. 248). Their position is summarised by Jones who, like Altshuler, relies on asserting the fact of flexibility and provides no evidence about costs.

> . . . the introduction of computer controlled production lines plus the introduction of much more flexible automation involving robots, automated handling, machining cells etc., have changed the economies of scale in production drastically. The use of robots instead of dedicated multi-welders, for instance, gives these plants a greater degree of flexibility to switch models in response to demand and reduces the cost of introducing new models and variants . . . A full range of cars can now be produced in one or two plants at a much lower total volume and at a cost which is competitive with much larger producers. . . .
> (Jones 1985, pp. 151, 152)

Against this we would argue that the new productive techniques are much less flexible than Jones supposes and the scale economies of the car business have not been fundamentally changed by the new techniques.

There can be no doubt that the process of car body building has been transformed by robots. It is now commonplace for 90 per cent of body welds to be made automatically and, in a modern car factory, most of these welds will be made by robots which are also extensively used in spraying. That explains why in most of the advanced countries, 50 per cent of industrial robots are installed in car factories. These robots are much more flexible than an earlier generation of dedicated jig multiwelders which could only weld one panel of a specific shape. The costs of multi-welders could only be covered on long runs and in Europe only VW (with the Beetle) built whole bodies with multiwelders. Ford and Fiat used them for "structural" components like floor pans which were not changed whenever models were face-lifted. Robots can be set up to perform a variety of spot welding operations on differently shaped panels for a set of models. Every European volume car manufacturer, even little Austin Rover, now operates robot body lines which can produce an output of 200–350,000 shells for two models and several variants on those models if the manufacturer so requires. But a substantial commissioning cost (for software, tools and fixtures) has to be incurred before a robot line is brought into use; one recent estimate suggests that 60 per cent of the cost of a robot system is accounted for by commissioning cost (see Williams *et al.* 1987). Most of this commissioning cost is model generation specific. When a new generation of models is introduced every five years or so the panel geometry will be different and, if the old robots are retained, they will have to be expensively recommissioned. Robots cannot be re-programmed for new models by pressing a few buttons. That is a myth.

It is also certain that the introduction of robots in body building has not transformed the scale economics of the cars business. More flexible automated technology does not allow the small scale producer to become more cost competitive than in the previous era when such firms relied on manual welding and spraying and dedicated automation was the preserve of the Americans and VW. When the commissioning costs of body building equipment is high, the large scale producer with long model runs retains an advantage when it comes to using and re-using body lines. Furthermore body building is only one process in the manufacture of motor cars and throughput requirement remains high in several other processes. Robots are being increasingly used in the final assembly of engines. But engines are still produced on transfer

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lines dedicated to the production of one engine type for a long period at a rate of 3000,000 units per year or more. For the foreseeable future, small firms in the European volume cars business will buy in engines which they cannot produce at a competitive cost. Even if new technology did change the balance of productive advantage between large and small firms, the large firm would still obtain a general advantage from its ability to spread development costs over longer runs. Because of inability to cover development costs, small car manufacturers always risk being demoted to assembler status.

The case of FMS is inevitably different in detail but it again serves to illustrate the basic discrepancy between reality and the romance of computerised flexibility. A 'flexible manufacturing system' exists where there is computer coordination of two or more manufacturing cells each of which would normally contain several machine tools; the cells will be connected by an automatic transport system which moves pallets, workpieces and tools between machines and to and from workpiece and tool storage; the whole is coordinated by a DNC computer which integrates all operations according to a master programme. (UN, 1986, p. 13). At first sight, the literature on FMS endorses the same doxa as the literature on car body building. The UN survey asserts that 'mass production as a concept is becoming more and more a thing of the past' (UN, 1986, p. 2). While there are familiar claims about added flexibility.

> In mass production environments, computer controlled machines will make it possible to add flexibility to the production system in the sense that the system can be used to manufacture several different product variants with minimal set up times. This opens up important potentials, for dividing large scale production into many smaller batches with the obvious purpose of reducing in-process inventory and achieving a faster adaptation to consumer preference, (UN 1986, p. 2),

But this literature is more sober, because it is not claimed that the availability of FMS changes the economics of the business of metal machining by tilting the balance of advantage against large scale production undertaken by the medium and large sized firm. That claim would be implausible because, as the survey evidence shows, FMS systems are expensive, deliver limited variety and have to be utilised at high volume. On our interpretation, FMS is a way of putting medium volume batch production on a capital intensive basis and therefore represents only a new twist on the old post Fordist story of volume and variety.

FMS systems are not cheap. The most comprehensive available

survey by the UN covers 339 FMS world wide. In this sample, 45 per cent of Japanese systems, 46 per cent European systems and 82 per cent of American systems cost over $3 million. Inevitably, therefore, most FMS are bought by medium and large firms who can afford this kind of expenditure. A large investment in FMS is only sensible if the enterprise has a substantial work load which offers a combination of the variety necessary to use the technical capability of the system and the volume necessary to secure high levels of capacity utilisation. This is another constraint on the adoption of FMS by medium and small sized firms. As the UN survey argued 'for small and medium sized companies it is often difficult to find a large enough product family in terms of the number of parts and the volume per part which over a long period of time will ensure a sufficiently high degree of utilization of FMS' (UN, 1985, p. 55). Smaller firms are also disadvantaged because they will usually lack the necessary in-house expertise to develop and run, a sophisticated custom built system.

The amount of variety delivered is very variable and quite obviously relates to the different requirements of particular enterprises and industries. For obvious reasons, most large firms who buy and use FMS do not want a machine which delivers industrial pump pistons this week and auto clutch components the next. Width of product envelope is built in at the design stage and usually determined by upstream and downstream process requirements. All the surveys show that Japanese FMS deliver substantially more variety than Western FMS. The UN survey showed that 49 per cent of Japanese FMS were able to produce more than 50 'variants' of a product; the comparable European and American figure was 17 and 37 per cent. Jaikumar (1986) has shown that FMS in American factories are used for longer runs than in Japanese factories. The implication is that Western firms are installing expensive over-sophisticated equipment which is not necessary for their business strategies and the end user requirements in the markets defined by those strategies. Variety of output is not an end in itself and many Western users of FMS are incurring hidden costs because they are buying facilities whose full potential will never be exploited.

Whatever variety is planned for and delivered, it is absolutely essential to obtain volume which guarantees high rates of utilisation. In this respect the crucial consideration is not batch size but the cumulative volume of all the batches produced through the year. And this cumulative volume is always high; in Jaikumar's (1986) survey, US FMS delivered an average of 17,000 parts per year while Japanese FMS delivered an average of 24,000 parts per year. When fixed costs are high, an FMS must be driven inten-

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sively near to the limit of capacity, if payback in 3 to 5 years is to be achieved. This is always achieved in Japan where two shift working is the norm and where nearly one third of the 60 FMS in Jaikumar's survey were being operated on a continuous three shift basis. As a Western observer reported after a tour of Japanese FMS, 'in all factories, the large product volumes and high throughputs were particularly impressive' (FMS Magazine, April 1986, p. 69). By way of contrast, the British financial experience of operating FMS is disastrous; in the New and Myers survey, more than half of the 64 plants which had installed FMS reported losses or no pay off. British production managers lack the technical ability to use even mundane metal working machinery in an intensive way (Daly and Wagner, 1985). And many British firms have a proven inability to find volume which is as necessary for FMS as for other more traditional forms of capital intensive process equipment which produces less variegated output.

We do not pretend to know the truth about new technology. We doubt whether there is one message in this bottle. If technological change is uneven in its nature and effects, it is unlikely to offer the same benefits to all enterprises and industries. But, in this context, our evidence does cast doubt on the universal validity of Piore and Sabel's over-confident assertions. And, whatever new technology does offer in the two cases which we have considered, it is not going to inaugurate a new era of flexible specialisation which restores those craft methods of production that lost out at the first divide' (Piore and Sabel, p. 5 see also p. 17). New generations of computer controlled equipment may deliver a more varied output but they do not restore an economic system based on redeployable productive resources and low fixed costs. That is a world which we have lost. When robot bodylines or FMS do not change the economics of the business in which they are installed, this new technology is likely to be controlled by medium and large sized firms who will not use it to create a workforce of independent craftsmen.

Piore and Sabel's vision of an artisan future is, like so much else in their book, plausible in some respects. If new technology has one general effect, it is to reduce the relative importance of semi-skilled direct labourers in the manufacturing workforce. In a company like Austin Rover, for example, only half the workforce in 1985 consisted of direct workers of the traditional blue collar kind. But that does not require any return to polyvalent craftsmen who have independent control over entry and the prospect of short term job security through work sharing. (Piore and Sabel, p. 126). These elements of the 'craft model of shop floor control' are not going to be re-created by the modern corporation. The

intentions of British managers are disclosed by their interest in, and enthusiasm for, the Atkinson 1984 'model' of labour control. In this schema, enterprises create an elite of multi-skilled workers whose training and skills are enterprise or plant specific and whose privileges as 'core workers' are granted and can be taken away by the company. The extent and significance of such labour central strategies remains to be investigated. Meanwhile, Piore and Sabel's schema is unhelpful because here again we have an instance where they simply project a stylised shadow of the past onto the present in a way which confuses our understanding of what is going on.

The benefits of flexible specialisation?

We cannot accept Piore and Sabel's diagnosis of what has gone wrong in the advanced economies. The notion of a crisis of mass production must be rejected for two reasons: first, it is based on a concept of mass production which is probably incorrect and certainly elides too many differences; second it is contrary to the available evidence on market trends and new technology. But it must be admitted that the advanced economies are not prospering and it is conceivable that flexible specialisation might provide a basis for industrial regeneration. This last section considers what flexible specialisation can deliver and comes to the conclusion that it is less than Piore and Sabel promise.

When the pre-conditions for a revived Keynesianism cannot, in Piore and Sabel's schema, be met, flexible specialisation is an attractive way forward. Flexible specialisation does not depend on a functioning national or international economic order which delivers a particular level or composition of demand. If flexible specialisation is to maintain technological dynamism, according to Piore and Sable it does require an integration of production into the local community. But this could be managed on a regional or local basis. If neither family nor ethnic identity provide suitable principles of integration in the modern advanced economies, the necessary integration could be provided by municipal or regional government. Within this framework, flexible specialisation provides a simple universal rule for choice of strategy at the enterprise and industry level. On Piore and Sabel's account, if new technology has one message and if there are general trends in the market place then for enterprises and industries there can only be one correct strategy of flexibility. Piore and Sabel do not formally draw this conclusion, but it is the logic of their position. In this context it is significant that in their long book, there is not one case where they commend inflexibility as an appropriate and effective con-

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temporary business strategy. Our question must be what can strategies of flexibility deliver?

Any simple rule which says 'the more flexibility, the better' would not always produce sensible results for the enterprise and the industry. In multi-process activities like steel making or car manufacture, the impact of technological change is almost always uneven and flexible automation is not the invariable correct answer to every question about the design of process technology. Best practice Japanese factories typically use a mix of dedicated 'hard' automation and flexible 'soft' automation. Leading Japanese automation experts like Makino insist that 'hard automation will always be very important' and cost effective because many process functions do not change frequently. In other cases, where flexible technology can be applied across a range of processes, it is impossible to produce the whole of an industry's output using flexible technology. For example, as long as steel mini-mills are scrap-charged, they can do little more than fill a niche in international markets where most of the output is produced in large-scale basic oxygen converters; the price of scrap would go through the roof if all the advanced countries used it as the basic raw materials for steel production.

At an enterprise level, choice of technology depends on the costs of available process technologies, the product strategy of the enterprise and the markets which are available within the limits of investment in distribution. Enterprise calculation is about making an appropriate choice within these parameters. And the choice which is correct for one enterprise will not necessarily be correct for another enterprise. This point is demonstrated by the contrast between VW's success at Wolfsburg with dedicated automation which is used for Golf body building and final assembly, and Austin's failure at Longbridge with the same kind of automation which is used for Metro body building. In both cases, choice of dedicated technology was consistent with the company's product strategy of producing a long life model with few variants. But the market position of the two companies was very different and dedicated equipment which could be intensively used by VW was underutilised by Austin Rover. The strength of VW's European distribution is such that the company can sell 750,000 Golfs each year while Austin Rover, which is pinned down on its home market, has difficulty in selling 150,000 Metros. With this kind of volume, it would have been more sensible for Austin Rover to choose a more flexible line where two or more different models could be built in whatever proportions the company preferred.

The contrast underscores the importance of executing strategy, and making choices work. If choice of technology should be related

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to the market, when technology has been chosen, execution is about ensuring the right level and composition of demand by managerial (and maybe political) action. This is an area where the British always do badly. We have elsewhere criticised 'gigantism' in British nationalised coal, steel and cars where enterprises naively pursued economies of large scale production (Williams *et al.*, 1986). In all three cases massive investment in modernisation only became totally disastrous when projected demand failed to materialise and the nationalised enterprises faced problems about the underutilisation of newly constructed capacity. The problem was not that the strategies were inherently absurd, but that they were executed ineptly because managers and politicians failed to secure the market that was necessary if the new large scale facilities were to run profitably. That adjustment of the market could have been made in at least two of our three cases. Austin Rover's managers could have invested in overseas distribution and the government could have given some preference to British manufactured cars. If that intervention was politically problematic, ministers could have easily prevented the CEGB from forcing down the price of power station coal which is the main product of British Coal.

From our point of view, the weakness of Piore and Sabel's position is that it virtually abolishes the role of enterprise calculation which, in their schema, must become a matter of identifying the particular implications of universal trends in technology and the market. As our examples show, this is an inadequate way of conceptualising the choices and opportunities which face enterprises and industries in the advanced countries. Institutional conditions ensure there are substantial differences in national ability to exploit such opportunities (Williams *et al.*, 1983) and the resulting differences in performance create further difficulties. Trade in manufactures between the advanced countries is a zero sum game, and in an open international economy, successful manufacturing countries like Germany and Japan gain trade share at the expense of unsuccessful manufacturing countries like Britain. The migration of manufacturing output and employment to the more successful advanced countries is a reality which Piore and Sabel avoid by positing the posibility of a future world where all can succeed through flexibility.

If Piore and Sable exaggerate the benefits which can be obtained from flexibility, more fundamentally they exaggerate the benefits which can be obtained from the regeneration of manufacturing. Their book is an argument about the possibility of a prosperous future based on manufacturing. But, any regeneration of manufacturing in the advanced countries is unlikely to solve problems about the distribution of social welfare which are becoming ever

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more acute. Piore and Sabel cover up these problems in their concluding chapters by putting before us a vision of industrial districts spreading out to create a new republic of craftsmen and smallholders. Against this in our view, institutional forces and free trade are likely to create regional and national islands of prosperity and to sustain substantial wage differentials between manufacturing workers and the rest – even within the islands of prosperity.

The most unsuccessful advanced economies like Britain contain regional islands of prosperity. As Hyman (1986) points out, the Thames valley in Britain provides a model of prosperity built on a diversified base of high tech manufacturing and services. Piore and Sabel attach special significance to those industrial districts like Prato and Emilio Romagna whose prosperity is supposedly built on a foundation of flexible specialisation. If national prosperity built on flexible specialisation is to materialise, then it would be necessary for these islands to expand so that they dominate the whole of the national economy. Before we could determine whether that outcome is plausible, we would need to know the proportion of national employment and output which these districts account for at present. Typically, Piore and Sabel provide no information on these points. In only one case are we given any figures and these relate to performance rather than extent; in Emilio Romagna all we are told is that wage levels and income per capita are rising relative to the rest of Italy and unemployment rates are falling relative to the rest of Italy (Piore and Sabel, p. 227). Such information does not allow us to determine whether industrial districts of this type are filling in occasional niches or can colonise the whole economy. In effect Piore and Sabel only provide homiletic examples of flexible specialisation's supposed success in regional economies. The Italian regions are like Samuel Smiles heroes; they show us all that, with the right kind of effort, it is possible to rise above the disadvantage of humble origins.

Where manufacturing succeeds (with or without flexible specialisation) that success only directly benefits a minority of the population. As Hyman (1986) points out, in all the advanced countries two thirds to three quarters of the workforce is outside the manufacturing section. In most of these countries the proportion employed in manufacturing is in relative decline and in unsuccessful manufacturing countries there are large absolute declines in numbers employed; the numbers employed in British manufacturing have declined by more than two and a half million in the past fifteen years (Cutler, 1986). Steady secular increases in labour productivity have been sustained in manufacturing since the industrial revolution and the expansion of manufacturing output has never required a commensurate increase in manufacturing

employment. To make this familiar point in a slightly different way, any increases in manufacturing (net) output are typically appropriated through rises in real wages rather than increases in employment (see Williams et al. 1987). The mechanics of appropriation ensure that the manufacturing sector is always a high wage sector in the advanced countries. Redistribution to the unwaged and to the low paid outside manufacturing will be necessary and such redistribution is most easily carried out by central government which in all the advanced countries has a dominant role in taxation and in secondary income redistribution through social security. That suggests the limits of the Piore and Sabel model of locally guaranteed prosperity. The dynamism of flexible specialisation might be secured by the integration of production into the local community. But, there are clearly limits on what municipal action can achieve. Most municipalities and regions lack the powers of taxation to achieve social objectives like a substantial redistribution of income.

* * *

In conclusion we have demonstrated that Piore and Sabel's basic opposition between mass production and flexible specialisation is unworkable because empirical instances cannot be identified; their meta history is contradicted by the case of Ford and suppresses the subsequent history of the assembly industries; their analysis of market trends and new technology is unconvincing; and their view of where flexible specialisation can take us is incurably romantic. Why then, has this mix of futurology and meta-history been represented as providing a serious and reliable guide to the modern industrial world despite its manifest conceptual and empirical weaknesses? Part of the answer lies in the fact that everywhere it strikes comforting and responsive chords. Thus in Britain Piore and Sabel's work provides a rationale for the local initiatives and plans for socialism in one municipality which have been increasingly popular over the past decade. The reception tells us more about the critical standards of this audience than about the real merits of the text.

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ANNOTATED BIBLIOGRAPHY

What follows is an extensive bibliography of works on technological change and work relations in Australia and New Zealand which were published during the 1980s. In 1981, Bill Ford, in conjunction with Margaret Coffey and Dexter Dunphy, published a comprehensive bibliography entitled *Technology and the Workforce*. This bibliography covered all of the works published during the 1970s and I advise you to consult it for these earlier studies. There were eighty-three items listed in connection with Australia and New Zealand.

This bibliography focuses on *empirical* studies of technological change. It immediately becomes obvious that there is a dearth of good research in the area. The industry coverage is extremely patchy, with an excessive focus on the banking industry (8 items) and the printing industry (6 items). There is surprisingly little work on mining or agriculture which are two key areas for the Australian economy. Equally, if we consider two areas which are important from a theoretical perspective (the process industries and the complex consumer goods sector) then there is a marked thinness of good empirical case studies. At the level of survey data, the only large-scale survey of any aspect of technological change is the work of Denis Davis, who examined the issue of skill changes. The work which is being carried out at the moment (e.g. the federal workplace industrial relations survey) should improve the picture during the course of the 1990s.

I would like to thank Glenda Maconachie for her assistance in compiling this annotated bibliography.

Empirical studies of technological change and work relations in Australia and New Zealand published during the 1980s

Australian Science and Technology Council (ASTEC). *Technological Change and Employment* (Report), (Parliamentary Paper no. 195/1983). Australian Government Publishing Service, Canberra, 1983.

This report aims to increase community understanding of the relationship between technological change and employment in Australia. It sums up information and views on technology and employment, identifies some of the

major issues and makes recommendations for consideration by government and various other decision-making bodies.

Bowles, M.L. & Lewis, M. 'Threats and opportunities for middle management: New technology and competitive banking'. ***Journal of Industrial Relations*****, vol. 30, no. 1, 1988, pp. 54–67.**

Since the 1970s the Australian banking industry has witnessed dramatic changes as a result of the introduction of new technology and competitive banking. Such conditions have produced a fundamental change in the nature and management of bank work. This paper discusses the impact of these changes for middle management. It concludes that for branch managers and accountants there has been a change in the content of their jobs, which is reflected in a reduction in their autonomy and decision-making power, with a new emphasis being given to marketing and selling activities. The new competitiveness in banking has encouraged staff to adopt an 'individual orientation' to their work. It is argued that such changes testify to a clear change in the management of the banking industry and suggest that middle managers in banks will become increasingly hostile or resistant to further change, with a consequent reduction in the number of middle management personnel, brought about by an increase in the technical control operations through computerisation.

Brereton, D. 'The job protection decision: Test cases and industrial reform'. ***Legal Service Bulletin*****, vol. 9, no. 6, 1984.**

This paper reviews the decision of the 'terminal, change and redundancy case' and its implications. The decision should lead to some significant changes in award provisions dealing with dismissal procedures and terminations due to redundancy.

Brocklesby, J. 'Technological change and the labour process: Towards an analysis of computerisation in the New Zealand trading banks'. ***New Zealand Journal of Industrial Relations*****, vol. 9, 1984, pp. 195–211.**

Within the labour process framework this paper examines the relationship between technological change and processes of control in the New Zealand trading banks. Adopting an historical perspective, the author rejects a crude deskilling thesis but concludes that computerisation has served nevertheless to enhance management control. Moreover, it is argued that recent changes in the climate of industrial relations in banking can only be understood within the context of changes in technology.

Burrows, G. 'Sugar cane harvesting: A case study in technological change'. ***The Australian Quarterly*****, vol. 54, no. 2, 1982, pp. 109–18.**

Much attention has been focused on the developments in, and technological impact of, electronics, while dramatic examples of technological change in Australian agriculture have been largely overlooked. This article examines the economic consequences, particularly the employment effects, of one example of technological change in agriculture.

Callus, R. 'Self-managed research and technological change: Towards industrial democracy in an Australian public utility'. *Economic and Industrial Democracy*, vol. 5, no. 4, 1984, pp. 469–94.

This paper examines, by way of a case study, how one union has formulated a policy on industrial democracy by involving rank and file members in an extensive research project. The project highlights the need for policies on industrial democracy to discuss the issues deemed to be a matter of concern to employees. Technology was found to be one such policy. The paper examines the applicability of conventional consultative arrangements, now common in many organisations, and how more appropriate structures can be devised that will ensure a more participative and effective decision-making process.

Carmichael, L. 'The process of technological change: A union perspective'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

This paper draws attention to the issues associated with the control of technology—that is, by whom and for what purposes. It is based on a report by the Assistant National Secretary of the AMWSU, and places recent technological change in an historical context, and also devotes particular attention to changes in the metal industry. It concludes that unions must become more involved in government and corporate decision-making processes, and, in pursuit of this, must adopt 'interventionist' strategies.

Carter, H.S. *Industrial Relations and Industrial Democracy in the Retail Industry*. Working Environment Branch, Department of Employment and Industrial Relations, Australian Government Publishing Service, Canberra, 1986.

This study of a selected sector of the Australian retail industry is structured around the policy discussion paper on industrial democracy. However, it does take into consideration technological and structural change in the industry.

Coffey, M. & Dunphy, D. 'Towards the paperless office'. *Work and People*, vol. 8, no. 2, 1982, pp. 3–11.

This article describes and evaluates the introduction of distributed word processing in IBM (Australia). The installed system integrates word processors throughout the country and will eventually be linked by satellite with IBM offices throughout the world. When fully implemented, the system makes the 'paperless' office a reality and has significant implications for staffing levels, efficiency and work satisfaction of employees.

Couchman, P.K. 'Towards the automated office: Technological change and office work in the New Zealand public service'. *New Zealand Journal of Industrial Relations*, vol. 9, 1984, pp. 177–94.

This paper examines Braverman's theory of the labour process in relation to the historical transformation of work in the New Zealand public service. It focuses upon two predominantly female occupations, those of typist and secretary. The paper also examines the range of control strategies available

to management, conflicts between groups of employees and technological change as a political process.

Cummings, K. *Outworkers and Subcontractors: Non-standard Employment and Industrial Relations*. Australian Government Publishing Service, Canberra, 1986.

This study examines three industries in which nonstandard employment practices are increasing: information processing, clothing and the building industry. While discussing the issue of industrial democracy for these workers, the study also explores the effects of these employment forms on working life and the role of technological change.

Curtain, R. 'Skill formation in manufacturing: Obstacles and opportunities'. *Human Resource Management Australia*, vol. 26, no. 4, 1988, pp. 7–22.

This paper discusses the prospects of achieving more flexible methods of skill formation in Australian manufacturing. Such flexibility is required because of the changing division of labour made possible by the ready availability of computerised technologies. The paper describes efforts by companies in the heavy engineering field to develop more flexible skill formation processes in their workplaces.

Davis, D.J. 'Technology and deskilling: The case of five principal trade areas in New South Wales'. *New Technology, Work and Employment*, vol. 3, no. 1, 1988, pp. 47–55.

This article summarises features of the current debate over whether new technology upgrades or downgrades skill and knowledge requirements and reports on how one thousand seven hundred tradespeople (craftspeople), interviewed between 1983 and 1985 in NSW, substantially reported an upgrading effect.

Davis, E.M. & Lansbury, R.D. 'Worker participation in decisions on technological change in Australia'. *Labour and Society*, vol. 12, no. 2, 1987.

Several developments have fuelled momentum toward increased industrial democracy in Australia. This is particularly the case with regard to decisions on technological change. Following judgments of the Arbitration Commission in 1984, workers covered by federal awards have been granted the right to be informed and consulted about decisions to implement new technology. In addition, several unions have negotiated agreements with employers which extend employee and union rights in the face of new technology. This article examines the factors which have encouraged greater industrial democracy and draws attention to employer and union involvement in decisions on technological change. Finally, factors limiting the practice of greater industrial democracy are examined.

Deery, S. 'New technology, union rights and management prerogatives: The Australian experience'. *Labour and Society*, vol. 11, no. 1, 1986, pp. 67–81.

This paper considers the need for the development of consultative machinery in the planning and introduction of technological change for union cooperation.

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Deery, S. 'Trade unions, technological change and redundancy protection in Australia'. *Journal of Industrial Relations*, vol. 24, no. 2, 1982, pp. 155–75.

Redundancy protection has become an important industrial issue in Australia over the past five years. Trade union interest in the question of job security has been heightened by fears that the greater use and application of computer technology will lead to significant reductions in the use of human resources. This article looks at the form and extent of redundancy protection in Australia and the ways in which trade unions have sought to press their claims for greater protection against the labour displacement effects of technological change. It concludes that in general Australian trade unions have met with very little success in establishing even minimum standards of employment security for their members.

Deery, S. 'Australian industrial relations and the management of technological change'. *Human Resource Management Australia*, vol. 20, no. 3, 1982, pp. 46–9.

Technological change and the way in which it is introduced has become an important industrial question in Australia. In recent years the Australian trade union movement has become increasingly restive about the general absence of adequate standards of job protection and consultative rights. Pressures on the unrestricted rights of management to introduce new technology without trade union participation have accordingly become more intense. This paper looks at these pressures and in particular the recommendations of the Committee of Inquiry into Technological Change in Australia. It concludes that the development of consultative procedures to deal with the consequences of changing technology are essential for stable industrial relations.

Deery, S. 'The impact of technological change on union structure: The Waterside Workers Federation'. *Journal of Industrial Relations*, vol. 25, no. 4, 1983, pp. 399–414.

A number of studies have looked at the impact of new technology on job security and the various ways in which unions have responded to this challenge, but little research has been undertaken on the effects of technology on the bargaining power of unions. Over the last decade the introduction of new cargo handling methods on the Australian waterfront has seriously threatened the negotiating and industrial base of the Waterside Workers Federation. This article examines the strategies adopted by the union in the effort to restore its organisational strength. These were largely directed toward an attempt to gain control on newly strategic groups of workers on the waterfront.

Department of Economics, University of Queensland. *Tradition in Transition: Technological Change and Employment in Banking*, (Working Paper no. 33). Department of Economics, University of Queensland, 1982.

A survey of private banks in Queensland was undertaken to ascertain the effect of technological change on the employment structure and attitudes of employees.

Department of Employment and Industrial Relations. *Technological Change and Industrial Democracy in the Western Australian Construction Industry*. Australian Government Publishing Service, Canberra, 1986.

This is a paper prepared by the Research Unit of the Western Australian Carpenters, Joiners, Bricklayers and Stonemasons Industrial Union of Workers.

Dufty, N.F., Savery, L.K. & Soutar, G.N. 'Banking industry employees and technological change'. *Prometheus*, vol. 5, no. 2, 1987, pp. 284–303.

The introduction of new technology has been of concern to banking unions but the chances of them effectively influencing such decisions are determined by the importance attached to the issue by members and their willingness to undertake industrial action. This paper reports a study which attempted to examine this issue by investigating union members' experiences with various types of new technology, their attitudes toward those technologies and various aspects of their work lives and also their willingness to undertake industrial action over the introduction of new technology into their workplace.

Edwards, R. 'Computer technology and unemployment'. *The Australian Quarterly*, vol. 59, no. 1, 1987, pp. 84–90.

The author examines the relationship between computer technology and unemployment in Australia. He argues that the prospect of a labour-free economy is falsley based on the perception that computers and other related technologies are exclusively labour replacing and second that the prospect is derived from an incomplete perception of how labour markets and the economy work.

Ellem, B. Technological change and trade union response in the clothing trades. In the possession of the author.

This paper considers the nature of recent technology in the clothing trade, and attempts to explain changes in response to them. Such changes and responses are examined in labour process terms, and the author argues that a deskilling hypothesis cannot adequately explain recent changes in the industry.

Encel, S. 'Social implications of technological change'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

Technological change has been a major influence in changing the character of working life since the eighteenth century. The author selects four particular areas for examination: centralisation of work organisation; fragmentation of the work force, gainful employment and the domestic economy; and the relations among work, education and training.

Encel, S. & Walpole, S. *Technological Change: Some Case Histories*, (Technology and Society Program Papers no. 2). University of New South Wales, Sydney, 1981.

This monograph was produced as a result of the CITCA Report in Australia. Two of the case studies, one dealing with the newspaper industry and one with the South Australian TAB, were contained within the Myers Report. The other two case studies, dealing with the insurance industry and industrial

chemical, were undertaken by the Technology and Society Program. These case studies demonstrate four major employment trends which result from significant technological change: centralisation of activities; changes in the composition of the work force; greater mobility of specialised personnel; and dwindling employment opportunities for unskilled, semiskilled and base-grade clerical workers.

Endersbee, L.A. 'Engineers and technological change in Australia'. *The Australian Quarterly*, vol. 57, no. 3, 1985, pp. 203–32.

Engineers, and related applied scientists, are the key skilled people in the introduction of new technologies in industries. The engineering services now offered by some international engineering organisations are so readily available and so expert that some Australian firms have considered it to be no longer economic to continue research, development and engineering design in this country. This seriously limits the capacity of such firms to be aware of technological developments of potential importance and to take advantage of technological opportunities.

Fells, R. 'The evolution of industrial relations in a changing environment'. *Work and People*, vol. 12, no. 2, 1986, pp. 13–18.

This case study shows how the processes of consultation and negotiation were used by management and the work force at BP's Kwinana refinery to adapt to major changes in their working environment. The paper suggests that these processes are part of a continuing evolution in workplace relations that depends on cooperation and a realistic view of the economic benefits.

Ford, G.W. 'Human resource development and the balance of skills'. In R.D. Lansbury & E.M. Davis (eds), *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

The author argues that the 'balance of skills' will be of critical importance in determining Australia's comparative advantage in an increasingly high technology oriented world. He examines a range of barriers which need to be overcome if Australia is to improve its balance of skill. These include inappropriate concepts, labour market restrictions, elitist employment policies and practices and industrial relations problems.

Forward, A. 'Technological change and women's employment'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

This paper argues that microprocessor technology promises increased wealth and reduced employment and that women are likely to be among those most adversely affected by these developments. Women are particularly vulnerable to the adverse effect from technological change because of their narrower occupational base and predominance in the secondary labour markets.

Frenkel, S. *Employee Participation in Decision Making in the Metal and Engineering Industry*. Working Environment Branch, Department of Employment and Industrial Relations, Australian Government Publishing Service, Canberra, 1986.

This report concentrates on developments in these industries in the period from 1982 to 1985. The study provides a background to the metal industry before focusing on participation and industrial democracy. While primarily concentrating on employee participation, the study does examine the impact of technological change on the industry and its workers.

Game, A. & Jacka, M. *The Whitegoods Industry: The Labour Process and the Sexual Division of Labour*. School of Behavioural Sciences, Macquarie University, 1980.

This was a study of changes in the whitegoods industry, concentrating on the effects of technological change on the work process, and on the sexual division of labour.

Game, A. & Pringle, R. 'Women, the labour process and technological change in the banking industry in Australia'. *Intervention*, no. 14, 1981, pp. 25–53.

The subject of this case study is the relationship between feminism, changes in the labour process and technological change. These issues are considered within the context of the overall development and structural situation of the banking industry in Australia.

Game, A. & Pringle, R. *Gender and the Labour Process*. Allen & Unwin, Sydney, 1983.

The major component of this book is case studies on the sexual division of labour as it has been both altered and yet preserved in Australia in six quite different industrial settings: whitegoods industry, banking, retailing, computer work, nursing in public hospitals and housework. The studies consider the transformation of the labour process through the impact of new technology, as well as considering a wider theme of capitalist control.

Giles, P. *Women Workers and Technology Bargaining*. Department of Employment & Industrial Relations, Women's Bureau, Australian Government Publishing Service, Canberra, 1985.

This article is the report of a survey undertaken on the impact of new technology on women's employment. The project focuses on two case studies within a framework of the position of women in the labour force and the union movement. The case studies concentrated on women's employment in telecommunications, and in the clothing and textile industries.

Griffin, G. 'Negotiating technological change in the Commonwealth Banking Corporation'. *Australian Journal of Public Administration*, vol. 42, no. 3, 1983, pp. 344–61.

In May and June 1981 Automatic Telling Machines (ATMs) were introduced into sixty-one branches of the Commonwealth Banking Corporation in New South Wales, Victoria, and the ACT. In contrast to union bans which had been imposed on ATMs in the private banking sector, the Commonwealth Bank Officers' Association (CBOA) actively supported the use of this new technology. After outlining the industry's industrial relations system, this paper examines the three-way process of negotiations involving the union, management and the federal government, which led to the introduction of ATMs. The terms of

agreement reached (a nineteen-day working month, early voluntary retirement after the age of fifty-five and a joint consultative committee on technological change in return for support for ATMs) are analysed and the factors which contributed to the absence of industrial conflict during the negotiations are discussed.

Griffin, G. 'Technological change and industrial relations in the banking and insurance industries'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

This paper discusses the impact of new technologies on the employees in these industries, and the responses of their unions. It notes the strategies adopted by the unions (which have included bans and a propaganda war waged via leaflets and television advertisements) but argues that they have made little discernible impact on the decisions made by the banking and insurance companies.

Guille, H., Lambert, D., Lavelle, M. & Sutcliffe, P. *Industrial Relations and Industrial Democracy in the Food and Beverage Industry*. Working Environment Branch, Department of Employment and Industrial Relations, Australian Government Publishing Service, Canberra, 1986.

This study considers the food and beverage industries in Queensland, and examines the industrial relations and industrial democracy structures existing within them. Changes in technology and their subsequent effects upon workers in the industries are considered.

Herbert, .N. 'Technological change and industrial relations: An employer's viewpoint'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

This paper outlines the case for the planned introduction of technological change, especially in the manufacturing industry, in order to ensure Australia's future economic survival. The impact of new technology on employment levels is regarded as being positive rather than negative, although manpower policies are advocated as a means of overcoming any employment problems that may arise. The author also accepts the need for employees to be properly informed and consulted on technological change at the workplace level.

Hill, J.D., Windsor, K. & Tregillis, S. *Prospects for Industrial Democracy in the Finance Industry*. Working Environment Branch, Department of Employment and Industrial Relations, Australian Government Publishing Service, Canberra, 1986.

This report explores the extent and possibilities of employee participation and industrial democracy in sections of the Australian finance industry. While primarily directed at participation and democracy, the study also considers the introduction and impact of technology, as well as the industrial relations framework within the industry.

Hill, R. 'From hot metal to cold type: New technology in the newspaper industry'. *New Zealand Journal of Industrial Relations*, vol. 9, 1984, pp. 161–75.

This paper examines the impact of radical changes in typesetting and composing techniques on three occupational groups employed in a major New Zealand newspaper. The paper stresses the importance of adopting a 'relational' approach to analyse the transformation of the labour process. The approach proceeds from the historically defined interests produced by the tensions and contradictions within and between organisations or groups.

Hill, R. & Gidlow, B. *From Hot Metal to Cold Type: Negotiating Technological Change in the New Zealand Newspaper Industry*. DSIR Social Series 3, Wellington, New Zealand, 1988.

This is an expansion of the previous item. It focuses on occupational change in the New Zealand newspaper industry. The issue of skill is examined at length and the authors conclude that:

> The sense of being a skilled worker is a social construct, based not simply on current job content and on the techniques and work habits learned during apprenticeship, but also on sets of cultural assumptions.

Howard, W. *Industrial Relations and Industrial Democracy in the Mining Industry*. Working Environment Branch, Department of Employment and Industrial Relations, Australian Government Publishing Service, Canberra, 1986.

The initial study undertaken by the author was a study of industrial relations in six isolated mines, from which this report on industrial democracy is drawn. The study considers the effect of three types of technological change on participants in the industry.

Huntley, I. 'Can the public service operate as a business?'. *Industrial Relations and Management Letter*, vol. 2, no. 29.

This detailed study of operations at Williamstown Navel Dockyard focuses upon a long history of industrial conflict and new management's plans for restructuring, reforms in work practices, improving quality control, productivity and morale.

Jackson, K.R. & Yerbury, D. 'Technological change in television and broadcasting: Electronic news gathering in the ABC'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

This paper presents a study of the substantial problems encountered in the ABC relating to the introduction of electronic news-gathering equipment. Two groups 'claimed' the new equipment and a lengthy demarcation struggle ensued. In addition, fears of deskilling and decreased job security surrounded the introduction of this technology.

Jitts, A. 'AMFSU J.A.M. study'. *Work and People*, vol. 11, no. 1, 1985, pp. 35–8.

This paper is a report of a study of the manufacturing industry in Western Sydney undertaken by the AMFSU. The study attempted to identify factors which, in the past decade, have led to the uneven pattern of growth and decline in the manufacturing industry in Western Sydney.

Johnston, R. & Rutnam, R. *The Effects of Technological Change on Employment in the Wollongong Region in the 1980s*. Science, Technology and Public Policy Series, Department of History and Philosophy of Science, University of Wollongong, 1981.

Detailed analyses have been made of the industrial and employment characteristics of the Wollongong region overall, and of the iron and steel, the coal mining and the finance industries. Studies of textiles, retail and government sector industries have also been researched on a preliminary basis. The data from these studies have been used to make general and industry-specific projections of the likely employment effect of technological change in the Wollongong region, and to propose some possible courses of action.

Kriegler, R. & Sloan, J. 'Technological change and migrant employment'. *The Australian Quarterly*, vol. 56, no. 3, 1984, pp. 216–26.

This paper seeks to establish whether or not migrant workers are a particularly vulnerable group in terms of job displacement and other changes associated with the introduction of new technology. It concludes that, unlike the case for women, there is no overwhelming case to be made that migrants are selectively disadvantaged by technological change.

Langdale, J. 'Telecommunications and electronic information services in Australia'. In J.F. Brotchie, P. Hall & P.W. Newton (eds). *The Spatial Impact of Technological Change*. Croom Helm, London, 1987.

The emergence of the information economy in industrialised economies has created considerable public awareness. While most attention has been directed toward examining the growth of information–equipment industries and the underlying technological changes in electronics and computers, there is a growth level of interest in those service industries whose development is reliant on the adoption of electronic information systems. This paper focuses on services that are heavy users of electronic information systems, such as banking, finance and business and financial information services.

Lansbury, R.D. 'Technological change and employee participation in the retail industry'. *Work and People*, vol. 8, no. 3, 1982, pp. 21–8.

Recommendations have been made by major employer associations and tripartite organisations concerning the involvement of employees in decisions which affect their working lives. Yet the extent of consultation by employers with employees about the introduction of new technology, as indicated by this study, was less than anticipated. A series of case studies found only modest involvement or participation by employees affected by the technological change.

Lansbury, R.D. *Technological Change and Employee Participation*, (Employee Participation Research Report no. 2). Department of Employment and Industrial Relations, Australian Government Publishing Service, 1983.

This is a full version of previous item which focuses on the retail industry and provides details of technological change in six firms. It considers the future impact of optical scanning systems.

Lansbury, R.D. 'Organisational change resulting from advances in technology'. *Human Resource Management Australia*, vol. 24, no. 1, 1986, pp. 22–6.

Increasing concern has been experienced about the decline in Australia's relative standing in the world economy. The reasons for economic decline are complex, but one important contributing factor has been the failure to develop adequate skills within the Australian labour force to cope with an increasingly complex technological environment. Australia is now importing a great deal of new technology from Japan and elsewhere but little attention is being paid to the implications of technological change for many of the traditional concepts of skills development, work and organisations which still dominate Australia.

Lansbury, R.D. & Davis, E.M. 'Technological change and industrial relations in Australia: An introduction'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

The issue of technological change on industrial relations has become an issue of major importance in Australia with the deepening of the current economic recession and increasing levels of unemployment. Although governments, employers and unions have agreed about the need to introduce technological change without causing undue social and economic hardship, the consensus appears to have had little impact on the manner in which changes have been implemented. The ways in which new technology have been introduced have exacerbated conflict in the workplace as, in many cases, traditional patterns of work have been upset, wage relativities have been disturbed and job security has been decreased.

Lawrence, G. Technological change and Australian agriculture: A sociological critique. 1988. In the possession of the author.

Australia is reliant upon a heavily mechanised, chemically dependent and energy-consuming agricultural system whose development is geared to the productivity-boosting technologies of transnational agribusiness. This paper considers the long-term decline in the terms of trade for agriculture. The competitive nature of the export market in rural products, protectionist measures in competing nations, reduction in the growth in demand in developing nations, and favourable seasons abroad are all partial explanations. The author suggests that the main force at work in this issue is the adoption of new technology.

MacIntosh, M. 'Technological change at Advertiser Newspapers Limited'. *Work and People*, vol. 10, no. 3, 1984, pp. 29–38.

This paper is based on a research project being undertaken by the author and M.G. Patrickson. It describes the introduction of a computer-aided newspaper production process at the *Advertiser* (Adelaide), and the reasons why the change in technology caused minimal disturbance to personnel.

Mallory, G.W. Technology and social change in the stevedoring industry: A comparative study in the impact of containerisation on the work force in Australia and Great Britain. M.Sc thesis, Griffith University, 1986.

This study is an examination of the impact of containerisation on labour employed in the stevedoring industry in Australia and Great Britain. It analyses the key issues that affected the work force of both countries before and after the introduction of this new technology.

Mandeville, T. & Macdonald, S. 'Technological change and employment in the information economy: The example of Queensland'. *Prometheus*, vol. 3, no. 1, 1985, pp. 71–85.

This paper presents the results of a study which identifies the extent of the Queensland information sector and assesses the role of information technology within it. In terms of employment, the information sector in Queensland in 1981 comprised about thirty-six per cent of the state's labour force. Information technologies are diffusing rapidly and widely into all sectors of the Queensland economy. Their impact on organisation and employment are investigated.

Mandeville, T. MacDonald, S. Thompson, B. & Lamberton, D. *Technology, Employment and the Queensland Information Economy*, (Report to the Department of Employment and Labour Relations). Information Research Unit, Department of Economics, University of Queensland, 1983.

The study seeks to determine which parts of the Queensland economy have experienced employment growth during the last decade. Its aim is to identify, and determine, the size of the Queensland information economy, and to assess the importance of information technology for industry performance and employment in the Queensland private sector.

Markey, R. 'Unions and planning for technological change in Australia'. *The Australian Quarterly*, vol. 56, no. 1, 1984, pp. 53–64.

The apparent increase in the rate of technological change in industry in recent years, largely associated with microchip technology, has raised a number of industrial relation issues. These include deskilling, job satisfaction, speed-up of the labour process, sharing the wealth of increased productivity, health and safety, the privacy of individual employees and, in the current economic crisis, redundancy. Few, if any, of the issues, are new to industrial relations. However, they have raised, in broader relief than is usual, the overriding issue of control of the labour process. New computer technology greatly increases the potential for management's supervision and control of labour.

Markey, R. 'A comparison of trade union responses to technological change in Britain and Australia'. *Work and People*, vol. 10, no. 2, 1984, pp. 29–38.

The majority of unions in Great Britain and Australia continue to deal with the introduction of new technology through productivity bargaining. Markey argues that unless unions catch up with and keep abreast of technological changes, their responses will continue to be reactive and defensive.

Marshall, I. *Industrial Relations and Industrial Democracy in the Printing and Newspaper Publishing Industries*. Australian Government Pulbishing Service, Canberra, 1986.

This study examines the prospects for industrial democracy in the printing and publishing industry, and concentrates on two occupational groupings (printers and journalists). The enterprises studied include large newspaper establishments that are major employers of labour and within which industrial relations issues are the subject of continuing debate and bargaining between management and labour. The report believes that the prospects for industrial democracy are best examined in the context of issues that these two occupational groups have had to confront. These issues relate mainly to fundamental technological change.

Mathews, J. *Technology, Trade Unions and the Labour Process*, (Working Papers in the Social Studies of Science). School of Humanities, Deakin University, 1985.

This paper examines technological developments in the labour process in Australia, and the issues facing unions. Case studies in telecommunications and the railways are used to consider the major issues.

Mathews, J. 'Technological change and union strategy'. In S. Frenkel (ed.). *Union Strategy and Industrial Change*. New South Wales University Press, Sydney, 1987.

The control of technology is a relatively new and exciting terrain of struggle for trade unions, and it requires the development of a comprehensive union strategy that goes beyond the bounds of existing policies. Some spectacular breakthroughs have been achieved, proving conclusively that workers, through their unions, can intervene to change their work conditions and the very production technologies with which they are required to work.

Mathews, J. *Tools of Change*. Pluto Press, Sydney, 1989.

Mathews analyses new technology in manufacturing and services and suggests that there are 'post-Fordist' forms of work organisation, skill formation and industrial relations. The widespread changes in technology should be grasped as 'tools of change' affecting a new cooperative accommodation between labour and management.

Maynes, J.P. 'Technology and collective bargaining: A union view'. *Work and People*, vol. 8, no. 3, 1982, pp. 29–36.

Technological change issues are now receiving increasing general attention both in Australia and overseas. Unions do not oppose technological change as such, but consider that its implementation should be accompanied by practices which cushion its impact upon employees. This article discusses developments and policies in this area. It identifies key problems associated with the introduction of new technology and outlines how these should be handled.

Muller, B. 'Bureaucracy, job control and militancy: The case of Telecom Australia'. In S. Frenkel (ed.). *Industrial Action: Patterns of Labour Conflict*. Allen & Unwin, Sydney, 1980.

The study is set in Queensland, and begins with a discussion of management and union organisation. Patterns of conflict are described, and two distinct industrial action profiles are identified. Muller also discusses the characteristics of accommodation between management and unions, focusing on the changing attitudes of the workers and the corresponding changes and continuities in management and union behaviour.

Pringle, R. & Jacka, M. *A Survey of Workers in the Whitegoods Industry*. School of Behavioural Sciences, Macquarie University, 1981.

The survey was carried out to canvas the view of workers in the whitegoods industry. It is a follow-up of a study undertaken by Game and Jacka in 1980 into changes in the industry and their effects. This paper is seen as complementing the previous research by seeking the view of those involved and affected by the changes.

Quinlan, M. 'Technological innovation and occupational health'. In R.D. Lansbury & E.M. Davis (eds). *Technology, Work and Industrial Relations*. Longman Cheshire, Melbourne, 1984.

The author investigates the implication of recent technological change for occupational health and safety. He argues that technological change has the potential to remove employees from existing hazardous situations, to provide better protection at work and better treatment of injuries, and also to provide safer materials. At the same time, however, much recent technological change has been associated with an increasingly stressful work environment in which dangerous chemicals and toxic substances have been all too common.

Reed, R. 'Making newspapers pay: Employment of women's skills in newspaper production'. *Journal of Industrial Relations*, vol. 29, no. 1, 1987, pp. 25–40.

Technological change blurs the distinction between 'men's work' and 'women's work' and raises questions concerning the nature and definition of skill. This case study focuses on changes in the organisation of work in the classified advertising telephone room following the introduction of computerised photocomposition into a Melbourne newspaper publishing organisation.

Riches, L.N. 'The dimensions of technological change and trade union responses'. In R.D. Lansbury & E.M. Davis (eds), *Technology, Work and Industrial Relations*, Longman Cheshire, Melbourne, 1984.

This paper outlines the array of issues faced by unions when their members are confronted by technological change. It argues that the major considerations have been the preservation of existing jobs and the provision of adequate employment in the future, workers and union rights in the decision-making process and the maximisation of the benefits associated with technological change. The article concludes that the response of Australian unions, until the late 1970s, had been limited and reactive.

Robbins, B. From people to machines: Technology in the banking industry. 1988. In the possession of the author.

This paper argues that the key feature underlying the pattern of technological

change in Australian banking is its branch structure. The author argues that the new technology allowed the expansion of banking services while deskilling traditional jobs, such that the branch structure is no longer required for a cost-effective banking industry.

Saw, J. Technology, skill and trade unions in the building and construction industry. 1988. In the possession of the author

This paper examines technological change, skill and trade union responses in the context of the Australian building and construction industry. Union attitudes and actions are briefly analysed, and two specific disputes are discussed to illustrate the relationship among technological change, skill and trade unions. The paper suggests that different groups of workers may experience different effects from technological change, with some being deskilled while others are unskilled. This therefore provides both threats and opportunities for the relevant trade unions.

Schulz, M. 'Technological change in the workplace: A union perspective on new technologies in a manufacturing environment'. *Work and People*, vol. 12, no. 2, 1986, pp. 3–12.

This article, from a manufacturing union perspective, points out the benefits of new technology, the effects on users and the pitfalls if the views of users, and other workers affected by its introduction, are not taken into account. It argues that each technological application should be tailored to the individual organisation and that consultation is an indispensable element before changes are introduced.

Selby Smith, J. 'Developments in micro-electronic technology and their impact on women in paid employment'. *The Australian Quarterly*, vol. 52, no. 4, 1980, pp. 415–31.

This paper examines the implication of developments in microelectronics for women in the paid work force. It is argued that because women are disproportionately concentrated in those occupations where the spread of microelectronics is likely to be comparatively rapid, women will disproportionately bear the burden of job displacement imposed by the widespread adoption of this technology.

Shannon, P. & Hogan, C. 'Technological change survey-consultation'. *Work and People*, vol. 7, no. 2, 1981, pp. 13–19.

A national survey was conducted in 1979 of technological changes in one hundred and sixty-five companies in the tertiary and manufacturing sectors. The survey was particularly concerned with the employment effects, consultative practices, work and job-restructuring and personnel practices associated with the introduction of new technology. This article looks at the extent and nature of consultative practices associated with the change.

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In this article the authors examine the response of overseas and Australian employers and unions to new technology. They study the effect of such technology on job security and labour adjustment. The authors analyse the effect of the Job Protection Case on present employment policy and conclude with an assessment of the ability of Australian industry and unions to assimilate new technology.

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This is a survey of industrial relations issues in connection with new technology, which considers job security, quality of worklife, industrial democracy, union organisation, wages and hours, and includes an extensive bibliography.

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Craig R. Littler is Professor of Management in the School of Management, University College of Southern Queensland. He completed his undergraduate work and Ph.D. at the London School of Economics. Subsequently, he has lectured and conducted research at The City University, The Open University, Cambridge University and Griffith University. Professor Littler has published widely on issues concerning work organisation, technology and management. In addition, he is the founding editor of the journal, *Labour and Industry*.

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